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and Maintenance of Way

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MABAM H. HAIG, Managing Editor NORMAN F. REHM, Editor
CHARLES A. BLAKE, Asst. Secretary WARREN EDWARDS, Manager

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Elimination of Grades and Curves

ECONOMIC procedure in railway construction calls for the elimination of steep grades and sharp curves on the trunk lines of our present railway systems. While this statement applied years ago, it is more applicable today on account of the changes which have been made in late years in railway equipment and schedules.

New construction through uneven sections of the country calls for extensive tunnelling through the mountains, viaducts across the valleys and a greater amount of cut and fill than would be deemed necessary on first consideration. Then we read of frequent realignments of old tracks for the purpose of reducing grades and lessening the degree of curves.

There are many reasons for these improvements in the alignment. One, the higher speed of trains, is not directly a question of economics, though it has been instrumental in causing the changes, oftentimes making it necessary in order to obtain a certain schedule. The train schedules between commercial centers have been lowered, whenever it was found possible by realignment to secure this advantage. There are so many illustrations that it is not necessary to mention any specific cases to corroborate this statement.

Another reason is the wear and tear on locomotive and rolling stock in general. The expense of repairs is greatly increased on lines of frequent grades as is shown by comparative estimates of the cost of repairs on several sections of long trunk lines. There is also combined with this the track repair which exceeds in cost of maintenance those tracks on level stretches of country.

Then there is the decrease in the number of derailments on roads which have eliminated such curves as it were possible to do away with and which have lessened the degree of curvature of others. While every precaution has been taken in the design and construction of these curves, there have been many accidents at these points either on account of speeds, exceeding that which the superelevation provided for, or on account of failure of the track due to wear and tear.

Thus, we see that first cost of construction is pitted against cost of maintenance of rolling stock and track as well as accident costs. It has been proven by the cost accounts of our railroads that it is unwise to reduce the first cost and subject the road to the accumlative losses in the future.

Block Signal Systems

STANDARDIZATION of block signal systems and apparatus is necessary. While one system secures excellent results, another, with few changes in details, is useless The variations in construction and operation cause trouble, which might be avoided by the adoption of certain tested standards.

The introduction block signal systems on our railroads was prompted primarily by an effort to obviate collisions. The development of the railway systems brought higher

speed locomotives, thereby making it necessary to use more caution in the prevention of accidents.

While the direct cause of the introduction has been as stated above, it was soon learned that the traffic over the lines could be increased by maintaining a space interval instead of a time interval between trains. This additional advantage gave a greater impetus to the installations of the block signal system. It was seen that the net returns of the investment in the block signal system were to be not alone in a decrease of the accident losses but also in the profits of an increased capacity of line.

The rapid development of signaling apparatus and improved construction of the track circuits has given a most efficient automatic block signal system. It has caused the displacement of the telegraph block system by the automatic on many double track lines and the installation of the automatic on even single track lines. If the space between distant and home signals is made of sufficient length so as to allow trains to be stopped before reaching the home signal, the automatic block system provides effectually against butting collisions on single track and gives as high an efficiency as is obtainable on the double track. The cost of the automatic, however, is about the same for a mile of single track as for a mile of double track, being about $1,500 per mile.

Besides the automatic block system, there is the locomotive cab signal and the automatic stop for the control of trains The locomotive cab signal consists of an automatic system of electric lights in the locomotive cab, a white light being used to indicate that the track is clear and a red light to indicate that the next block is occupied. The cab signal was designed for use without roadside signals, but it has only been used as an adjunct to the roadside block signal and to a very limited extent.

The automatic stop causes the application of the brakes if the engineer fails to regard the danger signal. It has not been used on interstate roads because in order to be not been used on interstate roads because, in order to be maintained between trains than the signal systems now in use demand. It is not deemed necessary if the improved block signal systems are operated efficiently. On account of the decrease in the capacity of the line and the practical difficulties incurred in its operation, it will in all probability not be adopted even though theoretically its advantages appear to make it desirable.

Experimental work is being conducted by the railroads and manufacturers of signals and signaling apparatus to further improve the present designs. These tests are being carried on even though it is believed that a high state of perfection has already been attained. Comparative results are desirable between the different methods of construction and operation of the signal systems, because there are many variations in the installations on the various roads. A standard is desired which shall be universal because it is on account of slight variation that danger sometimes attends an installation that would otherwise be perfect in its operation

Success of Railroad Men

IT is interesting to note the success attained by men trained in railroad service who have turned their attentions to other fields, and to forecast what the effect will be upon men now railroading and the inducements necessary to retain them. The railroad man learns early in his career that difficulties are made to be overcome and his schooling is of necessity one that prepares him for emergencies. If the foundation of a man's training has been in maintenance of way, he has learned to bear up under a great deal of grief, coming from many directions; he has learned to maintain his composure and coolly meet difficulties under all circumstances.

The continued wrangling with obstacles and the careful solution of problems so prepares him that it requires but little additional digging to specialize along other lines and meet the requirements therein demanded.

Many supply and manufacturing establishments are making up their forces from the ranks of railway men. They find such men valuable acquisitions because of their ability to give close attention to business, handle details without getting lost in the maze of minor affairs and because of an intelligent appreciation of the value of organization.

With such an attraction for the more efficient railway men it is incumbent upon the railway companies to arrange desirable salaries in order to hold the best talent now in the profession or be dependent upon the supply companies to provide engineering ability for railway interests. This would lead to costly experiments on the part of the railway in many cases.

The head of one of the largest establishments in the country catering to railway trade remarked some time ago, "I have no better men, no kindlier men, no men who are more anxious to do what is proper and right, than the very men we have secured from the railways."

Railways need well trained men now more than ever before, and the necessity for them will continue to increase indefinitely. Moreover, if a man is worth a large salary to a supply house he is worth more to the company who has trained him. The inevitable is here and the railroads should realize that they must pay their officers salaries somewhere near what they ought to be, instead of a ridiculous pittance.

The Field of Concrete in Railway Construction

IN EVERY railroad yard and along the right-of-way of almost all roads, one may see concrete used as a building material. The field of its usage is becoming more extended from year to year. It has been adopted wherever conditions favor its introduction. The advantages, which are obtained from the use of reinforced concrete in railway construction, are proved by its growing application.

The railroad yard contains reinforced concrete buildings, coal and cinder pits, etc. While an entire building may not be of concrete, the material enters into its construction to such an extent that it often identifies it with

this class of building. Coal and and cinder pits and also the engine pits of the roundhouse are constructed of concrete, both plain and reinforced. It seems that every new railroad yard contains a large amount of this material in the various structures.

Along the right-of-way there are reinforced concrete bridges, culverts and retaining walls. All track elevation plans include many designs of reinforced concrete structures. Recent issues of this paper contain articles illustrative of its usage in connection with track elevation work in the vicinity of Chicago. Then in some places, concrete telegraph poles are used. The subject of concrete poles was discussed recently by Mr. G. A. Cellar at the convention of Railway Telegraph Superintendents.

Concrete is used so extensively on account of its physical qualities, which make it more adaptable to certain construction than any materials previously used. It is not low cost alone, though the cost does influence its selection as it does every material. The life of a concrete structure is estimated to exceed that of any other because it is not subject to destruction by oxidation, the steel being enveloped by the concrete when reinforced, and because it withstands repeated vibrations, the fatigue of concrete under ordinary conditions of loading being slight. Concrete is also monolithic in its structure, capable of being formed into any desired shape. These attributes make it a very desirable material for railway construction work.

Telephone Systems in the Electric Traction Zone

New York Central and Hudson River Railroad

THE telephone system, which is in operation in the Electric Traction Zone of the New York Central & Hudson River Railroad, covers the territory from the Grand Central Station to North White Plains on the Harlem division and from Mott Haven to Croton on the

LOCATION MAP, ELECTRIC ZONE, N. Y. C. & H. R. R. R.

Hudson division. The location of the system is shown in the accompanying diagram, including power stations, sub-stations, signal sub-stations, cable terminal towers and circuit breaker houses.

The Company's telephone system is subdivided into four separate systems as follows:

1. Load Dispatchers' Telephone System.
2. Sub-station Party Line System.
3. General Service System.
4. New York Bell Telephone (Private Exchange).

Trunk lines connect the switchboards of the first three systems, allowing an exchange service between them.

1. THE LOAD DISPATCHERS' TELEPHONE SYSTEM.

The Load Dispatchers' Telephone System, connecting the two power stations and the eight sub-stations of the company, is for the exclusive use of the electrical operating force. The two 50-drop switchboards of this system are located at the power stations in the Load Dispatchers' office.

At each sub-station there is a 10-drop "wall type" switchboard, located in a telephone booth and provided with two telephones, each bridged to one telephone cord with two plugs. Two of the drops are connected to the power stations at Port Morris and Yonkers. The other drops are connected to the Sub-station Party Line System

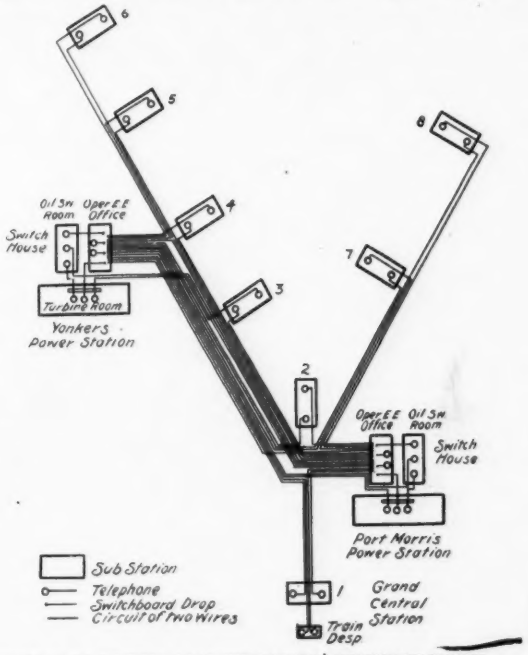
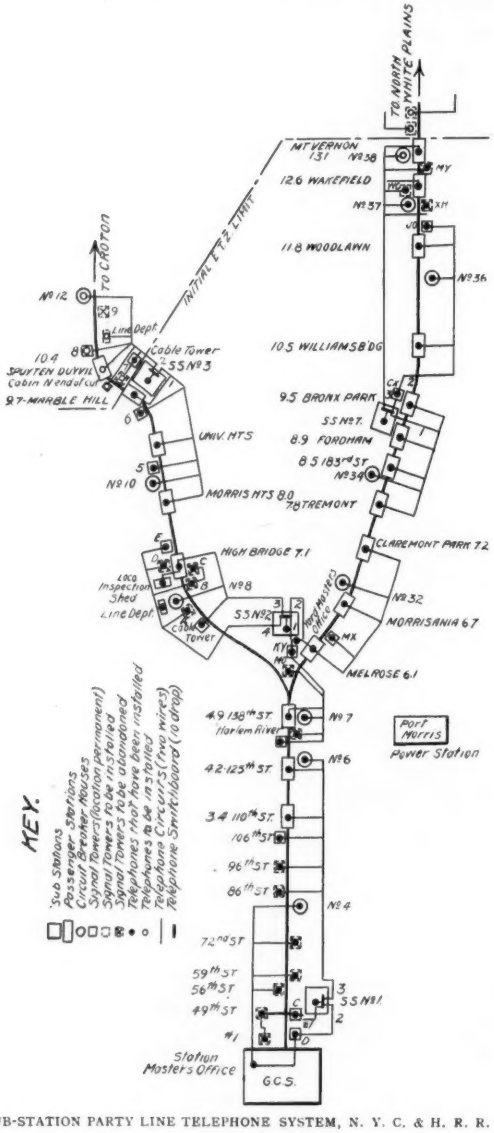


DIAGRAM OF CIRCUITS, LOAD DISPATCHERS' TELEPHONE SYSTEM.

telephones and the nearest General Service System switchboard. The diagram shows only the connections of the Load Dispatchers' circuit for power houses and sub-stations.

The telephone instruments are of the portable desk stand type, with a tubular standard and hollow base support, containing hook switch, retardation coil, condenser and terminal block for the receiver and desk stand cords. These instruments are furnished by the Kellogg Switchboard & Supply Company. With the telephones are used the Kellogg reverse type solid back transmitters and No. 12-A two-piece, hard rubber shell receivers with 2500-ohm ringers, 5-bar generators, No. 1-A induction coils and "Columbia" dry batteries.

The switchboards are of the Kellogg "desk type" with some special changes made in order to give ample desk



SUB-STATION PARTY LINE TELEPHONE SYSTEM, N. Y. C. & H. R. R. R.

room for the operator to handle clerical work. The line signals consist of 50 self-restoring tubular drops with answering jacks. The keyboard contains ten pairs of cords, ringing and listening keys, and one battery switch. Then there is also a night alarm with its auxiliary apparatus and one operator's telephone set complete with hand generator key and ringing transformer.

The telephone cables which have been installed are of two kinds, i. e., lead covered, paper insulated and rubber covered, braided. The former is used for underground ducts and aerial constructions, while the latter is run in pipes on the Park Avenue viaduct. At all sub-stations, cable towers and power stations, the Load Dispatchers' and General Service circuits end in a cable terminal cabinet where all circuits are bridged to jacks, thus allowing circuit tests and interchange of circuits in times of emergency. These cabinets contain heat coils and lightning arresters at places where the wires are wholly or partly aerial. In the Harlem River, standard submarine armored type telephone cable has been installed.

In case of aerial open wire construction, No. 10 B. & S. copper wire is used and strung on the Western Union Company's poles along the railroad company's right of way. The wires are supported on Western Union standard glass insulators and pins, and are transposed in accordance with the standard practice of the Bell Telephone company.

2. SUB-STATION PARTY LINE TELEPHONE SYSTEM.

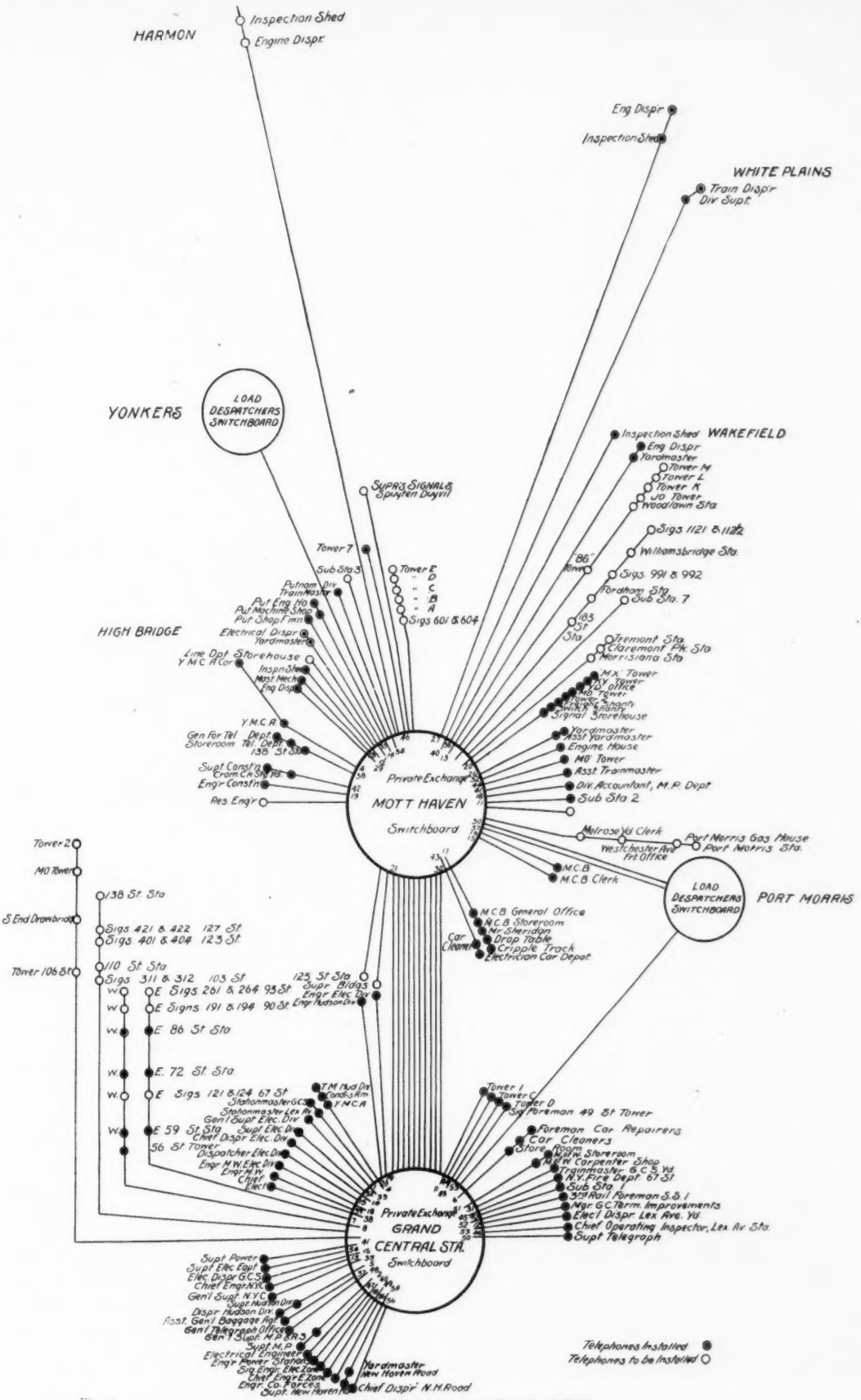
This party line system is for the use of employees along the right of way in communicating with the sub-station feeding their districts. It connects passenger stations, circuit breaker houses, signal towers, etc., to the sub-station controlling the district as shown in the accompanying diagram.

These telephones are bridged to a party line, not exceeding seven for a single circuit. The party lines are connected to the "wall type" switchboard in the substation where the Load Dispatchers' and General Service circuits terminate. This switchboard affords intercommunication between these systems, the connections being made by the sub-station operators by means of plugs and jacks.

The sub-station party line system uses several circuits in the General Service System cable where these cables have been installed. The connection is made through either a cable tap or opening, one of which is located at nearly all passenger stations. In other cases separate aerial circuits are installed. The connections of the telephones to the cables or lines are made with twisted pair No. 14 B. & S. copper wire.

The telephone instruments are of the Kellogg desk type. The passenger station telephones are installed in wooden boxes, located on the station platforms. At the circuit breaker houses, telephone boxes, constructed of iron and set in the brick wall, are used, having two doors, one opening inside and the other outside of the building. In the signal towers the telephones are located on shelves or desks.

We are indebted to Mr. Carl Schwartz, Eng. of Power



GENERAL SERVICE RAILROAD TELEPHONE SYSTEM.

Stations, for the information and plans contained in this article.

THE GENERAL SERVICE SYSTEM.

The general service railroad telephone system has no connection with any telephone central office. The two switchboards are located at the Grand Central Station and Mott Haven. The diagram shows the layout of the system, indicating also how much is completed at the present time.

The duct or pipe system extends from the Grand Central Station to Mott Haven. From that point, it passes up the Harlem division to the Botanical Gardens and up the Hudson division to the Putman Railroad Bridge crossing about ¾ of a mile beyond Mott Haven Junction. There is also a branch, reaching out from Melrose Junction to the Port Morris Power House

In the conduit system, two separate sets of standard lead covered cables are carried on opposite sides of the track. From the Putnam bridge north on the Hudson division to Yonkers Power House, two lead cables are carried aerially on the telegraph pole line and, from the Botanical Gardens on the Harlem division north to Woodlawn, one lead cable is carried aerially.

The sets of cables are in duplicate. The smaller one of the cables is assigned for the exclusive use of the Load Dispatcher's System. The other line of cables, known as the General Service cables, carries the wires for the General Service and Sub-Station Party Line systems.

All apparatus, including switchboards and instruments, was purchased from the Kellogg Switchboard & Supply Company.

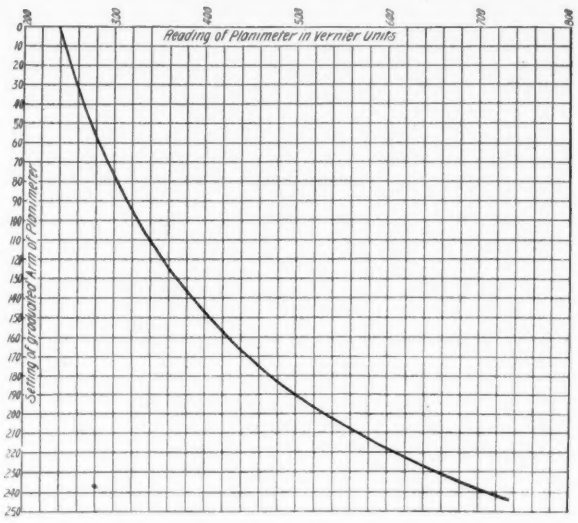
The installation of all the cables and apparatus of the first three systems was handled by the Operating Department, under the supervision of an electrical committee connected with the Engineering Department.

We are indebted to Mr. A. B. Taylor, Supt. Telegraph, for information and diagrams contained in this description.

Calculation of Excavation in Railway Cut

THE method of determining directly the number of cubic yards of excavation in a railway cut by means of the planimeter is based on the setting of the graduated arm. It is a method which is used in the office of Burns & McDonnell, civil, hydraulic and sanitary engineers, Kansas City, Mo.

The problem is outlined as follows: When anyone is performing calculations to get the number of cubic yards of excavation in a railway cut, it is presumed that the distance between stations is uniform. It is presumed also that he is using the method of end areas, and that the prismoidal corrections will be applied to the results later. What he does then is to determine the ends areas in square inches of paper, multiply this result by a constant to reduce to square feet of actual surface, multiply the last result by the distance between ends and divide by 27 to reduce the result to cubic yards. Now instead



CURVE FOR USE WITH PLANIMETER FOR TRIAL SETTINGS.

of going through all this multiplication and division, he could just as well have used a definite setting on the graduated arm of the planimeter, such that these constants of multiplication and division are all absorbed in the reading of the instrument. Anyone who is familiar with mathematical calculations will have no difficulty in taking the brass disc which accompanies each planimeter and determine by trial where to set the graduated arm in order that one revolution of the pointer around this disc will give a result on the vernier equal to the number of cubic yards in a section of cut whose average end areas equal the area of this brass disc.

Each instrument must be calibrated, because the settings of the arm for one instrument will not apply for another.

The curve, here shown, is for use with a planimeter in the office of Burns & McDonnel, to facilitate in securing settings for trial, when it is desired to find where to set the graduated arm in order to give a reading on the vernier equal to some predetermined quantity.

If a common scale is used for all profiles in the office, a curve may be platted for an instrument with widths of trench as abscissas and settings of the graduated arm as ordinates. A point on the curve may be determined as follows: Assume the horizontal scale of the profile to be 200 feet to 1 inch and the vertical scale 10 feet to 1 inch, and the area of the guide disk of the planimeter to be 4 inches. In that case, 1 sq. in. on the profile represents 2,000 sq. ft. of section of the trench and the area of the guide disk of the instrument represents 8,000 sq. ft. For a trench 2 feet wide, the area of guide disk would represent 592.6 cu. yds. of material. It would require that the arm of the planimeter be set at 216.2, in order to obtain a reading of 592.6 on the vernier wheel.

The readings are determined by trial for each planimeter in a short time and, if care is taken in finding these values, they may be depended upon to give accurate results.

Sixth Street Viaduct, Kansas City, Mo.

THE Sixth street viaduct, now commonly called the Intercity viaduct, consists of a main structure and several laterals. The main structure extends from Sixth and Bluff streets in Kansas City, Mo., to Fourth and Minnesota avenues, Kansas City, Kan. The length, including an earth approach 381 feet long at the Kansas end, is 8,400 feet.

This main structure consists of a double track street railway, along the north side, and an asphalt paved roadway resting on a reinforced concrete base for vehicle traffic. The roadway from Sixth and Bluff streeets to a point near Mulberry street is 38 feet wide in the clear, and from this point westward it is 30 feet wide. Two laterals lead off from the main viaduct toward the south near Mulberry street. One of these laterals will terminate at Twelfth and Mulberry, the other is already completed and lands at street grade at Ninth and Hickory streets.

EAST END OF KAW RIVER BRIDGE.

The Ninth and Hickory street approach is 20 feet wide in the clear and the Twelfth and Mulberry street approach 24 feet wide in the clear. Both are paved with asphalt on reinforced concrete base and provide only for highway travel.

The main viaduct includes a bridge over the Kaw river, which consists of two 300-foot spans. These spans are of double intersection Warren girder type and are solid riveted throughout. The substructure for this bridge consists of three concrete piers. All are carried to bed rock. The channel pier and that on the east shore were sunk by the pneumatic process. The west shore pier landed on bed rock at an elevation above water level.

The main viaduct, where standard, is constructed in bays consisting of seven 45-foot spans and one 30-foot tower span, the tower being braced longitudinally with riveted sections in order to take care of any longitudinal thrust from expansion or other causes. Between each pair of the towers is an expansion joint, as indicated on the accompanying plans. The structure is braced laterally by knee braces from the cross girders to the columns placed at such height as to provide proper clearance for railway tracks beneath the structure.

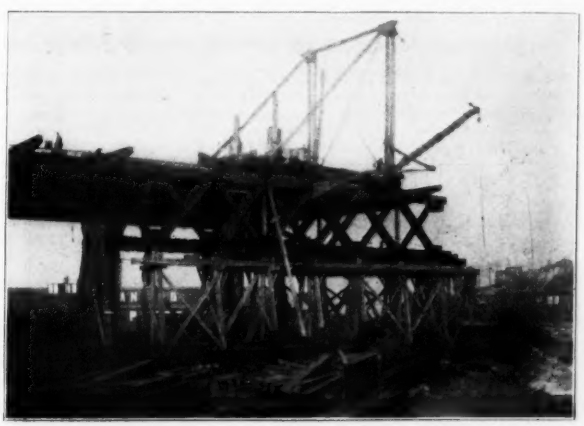
The grades on the viaduct are as follows: Beginning at the east end there is a 1 5/10 per cent descending grade for 843 feet; a 5/10 per cent descending grade for 2,362 feet; a 5/10 per cent ascending grade for 2,091 feet; a 74/100 per cent ascending grade for 45 feet; a 1 5/10 per cent ascending grade for 1,415 feet, ending at the east end of the Kaw river bridge; a 5/10 per cent ascending grade for 609 feet on the bridge, and a 1 5/10 per cent ascending grade for 1,035 feet to the west end of the viaduct. In the alinement, there are three 3-degree curves, which are 683, 653 and 190 feet in length.

All of the steelwork for the entire viaduct and approaches was furnished and erected by the Riter-Conley Mfg. Co. of Pittsburg, Pa. Mr. John P. Wagner was the resident engineer for this company. The erection of the steel work was begun in February, 1906, and the entire main viaduct was completed and opened for traffic on January 29, 1907. The Hickory street lateral was opened in May of this year. The total amount of steel in the entire structure is about 15,000 tons.

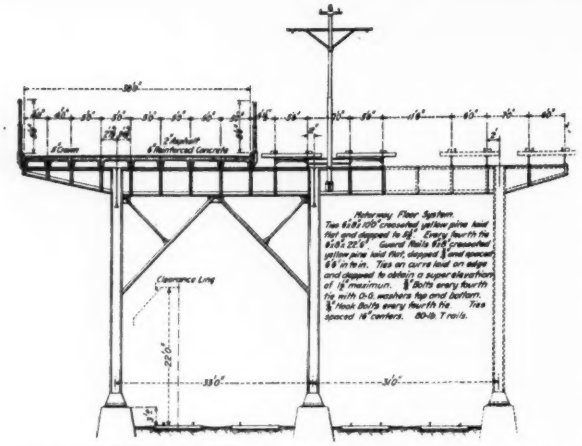
All reaming for field connections was performed in the field, after the metal was erected, by means of pneumatic reamers. All shop work was subpunched and reamed.

A typical cross-section of the viaduct is given, showing the future extension for additional tracks. The columns between 27 and 31 feet in length are made up of two 15-in. 33-lb. channels, a ½ x 16 in. plate and four 5 x 3 x ⅜ in. angles. Other columns are made up of heavier channels, but the diaphragm remains the same. The floor beams are 15 feet apart and are 52-in. plate girders with a ⅜-in. web and 6 x 6 x ½ in. angles. On top of the floor beams there are 12-in. 3½-lb. I-beams, placed 5 feet on centers as shown. Under each rail of the tracks there is an 18-in., 55-lb. I-beam. Longitudinal bracing is usually provided in every seventh panel on tangents, and every fifth panel on curves.

The entire main viaduct is located on alluvial soil, a large portion of which has been recently deposited by the Kansas and Missouri rivers. It was, therefore, necessary in order to provide suitable foundations for the via-



ERECTION OF 140-FT. PAN, KAW RIVER BRIDGE.

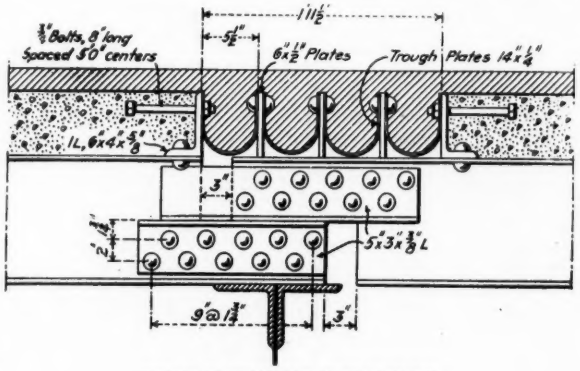


CROSS-SECTION THROUGH VIADUCT, SHOWING FUTURE WIDENING FOR ADDITIONAL TRACKS.

duct columns to drive piling beneath all pedestals, excepting a few on the approaches and near the two terminals. As the low water level is about 30 feet below the tops of the pedestals, it was decided in order to save the large amount of concrete necessary to carry the foundations to this depth to use concrete piling. These concrete piles were molded on the ground. The concrete mixture used was composed of the following: One part Portland cement, three parts sand, and five parts finely broken stone. These piles are 10 inches in diameter at the small end and 14 inches at the large end, and are of octagonal cross-sections. Each pile was reinforced with four corrugated steel bars. When the work was first started in August, these piles would harden sufficiently to drive within one week from the time they were molded. They were driven with a water jet, and whenever the piles would stick, they were churned up and down by raising the hammer, follower and pile and allowing them to drop. There was little more difficulty in driving these piles than ordinary timber piles. The molding of these piles was started in August, and during the months of August, September and October very good results were obtained. Cold weather, however, later on in the season, so retarded the setting of the concrete piling that the further use of such piles during that season was rendered impracticable. As it would have been necessary to wait until the following spring before completing the work, it was decided, after driving 800 concrete piles, to substitute creosoted yellow pine piles in their place. About 3,000 timber piles were driven in the foundations, the entire foundation work including the Kaw river bridge piers. All of the pedestals for the main viaduct were put in place between the 21st day of August, 1905, and the 13th day of February, 1906.

The entire foundation work was performed under a general contract taken by Mr. Jas. F. Halpin of Kansas City, Mo. The driving of the piling was sublet by Mr. Halpin to the Foundation Company of New York, and the piers of the Kaw river bridge were sublet to Messrs. Kahmann & McMurry of Kansas City, Mo.

The roadway flooring is formed of a 6-inch reinforced concrete base covered with a 2-inch asphalt surface. The steel beams supporting this floor are spaced about 5 feet on centers, and the reinforcing consists of ½ inch Johnson corrugated bars, spaced 6 inches on centers at the bottom of the concrete running transversely and 12

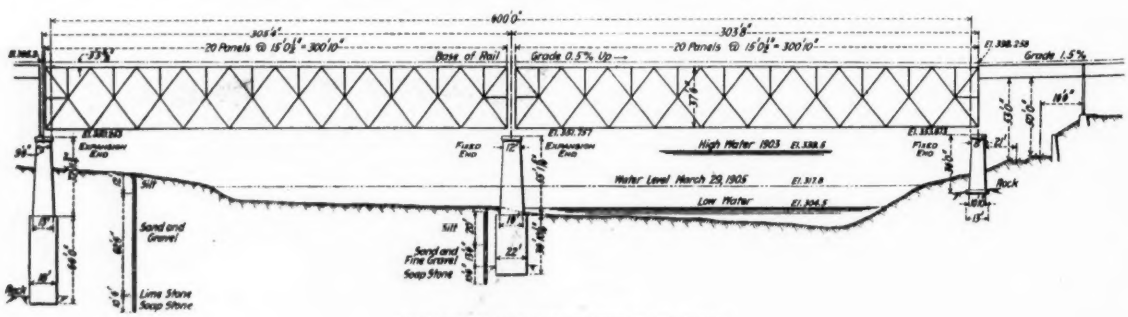


DETAIL OF EXPANSION JOINT IN FLOOR.

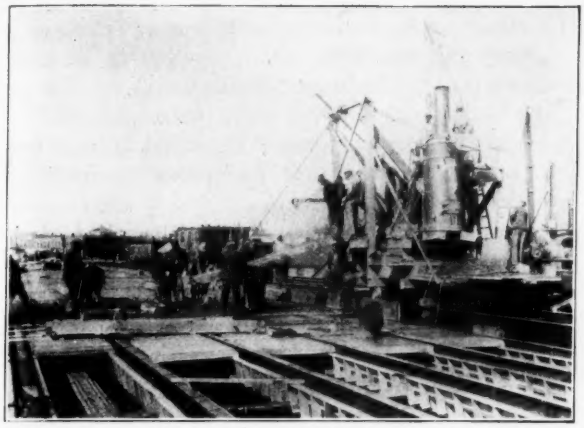
inches apart in the top running transversely. Longitudinal bars are spaced 12 inches on centers in both the top and bottom. These longitudinal bars were used in order to take care of the expansion and contraction, and to secure a better distribution of concentrated loading over the floors.

The concrete flooring was constructed by the Expanded Metal & Corrugated Bar Co. of St. Louis, under the immediate supervision of Mr. Geo. R. Heckle, Supt. for that company.

The ties are 6x8 inches by 9 feet, spaced 14 inches center to center. Every fourth tie is continuous across both tracks. All of the timber used in the ties and guard rails is long leaf southern yellow pine, treated with 12 pounds of creosote per cubic foot.



ELEVATION OF BRIDGE OVER KAW RIVER.



FORMS FOR CONCRETE ROADWAY, SIXTH STREET VIADUCT.

The following is a general summary of materials used in the construction of this work:

15,000 tons of steel
30,000 cubic yards of crushed stone
17,000 cubic yards sand
40,000 barrels cement
107,000 lin. ft. of creosoted timber piling
24,000 lin. ft. of concrete piling.

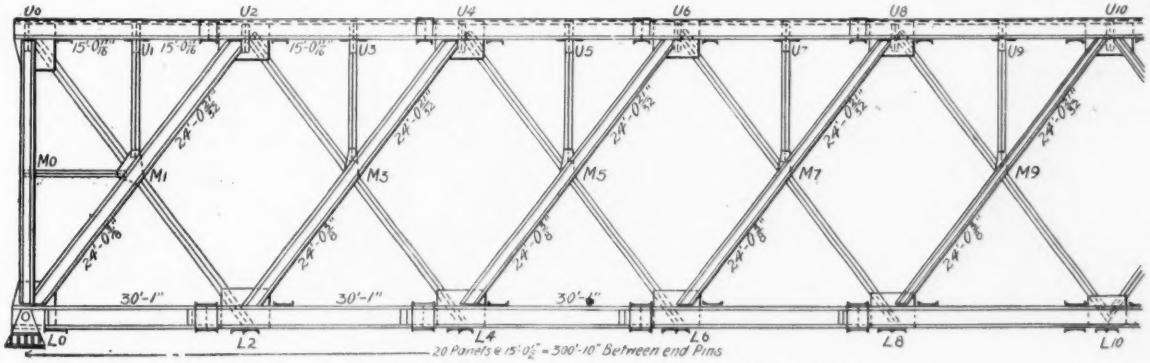
The structure is lighted throughout with 22 candle-power tantalum lamps, fed by a 3-wire system, current used at 110 volts. These lights are spaced 36 ft. on each side of the roadway and are so arranged that they stagger from side to side, thus giving one light to every 18 ft. of structure. The distribution of light is perhaps the best of any roadway in the world. A newspaper can be read at night at any point on the roadway. The electric lighting installation was performed by the Squire Electric Company of Kansas City, Mo.

LOADS AND SECTIONS.

	LOAD (Lbs.)				SECTION (Sq. ins.)		
	D.L.	L.L.	I.L.	Tot.	No. Ang.	No. Pl's	Total Area.
U0U2	384,000	141,000	34,000	559,000C	4	2	53.45
U2U4	1,059,000	398,000	96,500	1,533,500C	4	5	93.84
U4U6	1,561,000	595,000	144,000	2,300,000C	4	5	138.49
U6U8	1,897,000	723,000	175,000	2,795,000C	4	7	168.49
U8U10 ...	2,065,000	787,000	190,500	3,042,500C	4	7	183.49
L0L2	407,500	161,500	39,000	607,500T	4	2	50.00
L2L4	1,079,000	418,500	101,000	1,598,500T	4	4	108.50
L4L6	1,582,000	611,000	148,000	2,341,000T	4	6	162.50
L6L8	1,919,000	739,000	179,000	2,837,000T	4	8	194.00
L8L10	2,085,000	803,000	194,000	3,082,000T	4	8	212.00
L0U0	534,000	203,000	49,000	786,000C	4	2	57.24
L0M1	388,500	397,000	186,000	972,000C	4	2	73.74
M1U2	358,000	359,000	172,500	890,500C	4	2	73.34
L2M3	306,000	320,000	157,500	783,500C	4	2	59.12
M3U4	276,000	286,000	143,000	705,000C	4	2	59.12
L4M5	224,500	254,000	130,000	608,500C	4	2	46.00
M5U6	194,000	224,500	117,500	536,000C	4	2	46.00
L6M7	142,000	192,500	104,000	438,500C	4	2	33.50
M7U8	112,000	166,500	91,500	370,000C	4	2	33.50
L8M9	60,000C	143,000C or 63,500T	81,000C or 38,500T	284,000C or 42,000T	4	2	23.92
M9U10 ...	30,000C	121,000C or 81,000T	69,500C or 48,000T	220,000C or 99,000T	4	2	23.92
M0M1	.....	.....	.....	.....	4	..	10.00
M1U1* ...	47,000	89,500	65,000	201,500C	4	..	18.00
U0M1	379,500	357,500	168,000	905,000T	4	1	60.88
M1L2	349,500	320,000	157,500	827,000T	4	1	60.88
U2M3	297,500	288,500	141,000	726,500T	4	1	49.44
M3L4	267,500	254,000	130,000	651,000T	4	1	49.44
U4M5	216,500	222,000	113,500	552,000T	4	1	39.25
M5L6	185,500	192,500	104,000	482,000T	4	1	39.25
U6M7	133,500	169,000	90,500	393,000T	4	1	27.62
M7L8	103,500	143,000	81,000	327,500T	4	1	27.62
U8M9	52,000T	119,000T or 79,500C	67,500T or 48,000C	238,500T or 75,500C	4	..	24.24
M9L10 ...	22,000T	97,000T or 97,000C	57,500T or 58,000C	176,500T or 133,000C	4	..	24.24

*M1U1, M3U3, M5U5, M7U7 and M9U9 are similar.

Kansas City, Mo., has a population of about 250,000 people and occupies the eastern portion of the Kaw valley and the hills east thereof; while Kansas City, Kan., a city with a population of about 90,000 people, occupies the western side of the Kaw valley. Practically all the freight depots of the various railroads serving the two cities are located in the Kaw valley in the vicinity of the terminals of the two lateral branches of the approaches to the main structure. The average difference in the elevation between the level of the Kaw valley and the



SECTIONAL DIAGRAM OF KAW RIVER BRIDGE, SIXTH STREET VIADUCT

high portions of the two cities is approximately 100 feet. The entire bottom district is practically a network of railway tracks, and owing to the heavy grades and the inconvenience of the grade crossings, the wagon traffic between the high levels and the valley is greatly impeded.

For a great many years the subject of suitable connections between the various districts by means of free viaducts was agitated, but the amount of money involved in the solution of the problem and the difficulty of getting the two citites to agree simultaneously on a fixed plan made it impracticable to provide free facilities.

In 1904, Wm. J. Knepp of Kansas City, Mo., formulated the plan of providing the necessary viaducts as a private enterprise, the income to be secured by collecting highway tolls and from rental secured from the street railway tracks. A corporation known as the Kansas City Viaduct and Terminal Railway Company was organized with a capital stock of $3,000,000 to build, own and operate the structure. The necessary franchises were obtained from the two municipalities, and the proposition was financed by New York and Boston bankers. The actual construction was begun in August, 1905.

The firm of Waddell & Hedrick, Kansas City, Mo., was originally retained as consulting engineers for this work, but upon the dissolution of that firm the completion of the work was entrusted to Mr. Hedrick.

Development of Freight Yards, Atlanta, Ga.

Southern Railway

THE rapidly increasing freight business on the Southern Railway at Atlanta, Ga., made it necessary for the company to enlarge its freight facilities. As the business increased from year to year, the old yards were extended and improved until there seemed to be no possibility of further development. It was then decided to select a new location for a yard which would take care of the present needs and provide for the future.

The city of Atlanta is about 1,000 feet above sea level, the surrounding country being very broken, and generally sloping toward two water courses, the Chattahoochee river on one side and South river on the other, these streams being five or six miles from the city. The task of selecting a site which should be convenient and serve the several main lines of the Southern Railway entering the city, and within a reasonable distance of its connections, was one of considerable difficulty. After much consideration, Mr. C. H. Ackert, vice-president and general manager, decided on a location lying north of Marietta road, on the main line between Atlanta, and Chattanooga and Birmingham.

The old line at this point has a nearly uniform grade of about 33 feet per mile, descending to the Chattahoochee river, the alignment being a succession of sharp curves, as indicated in sketch.

As will be observed, the plan provides for abandoning the old line and building a double track of very much better alignment, involving thorough work of heavy cuts and fills, much of the excavation being through solid granite.

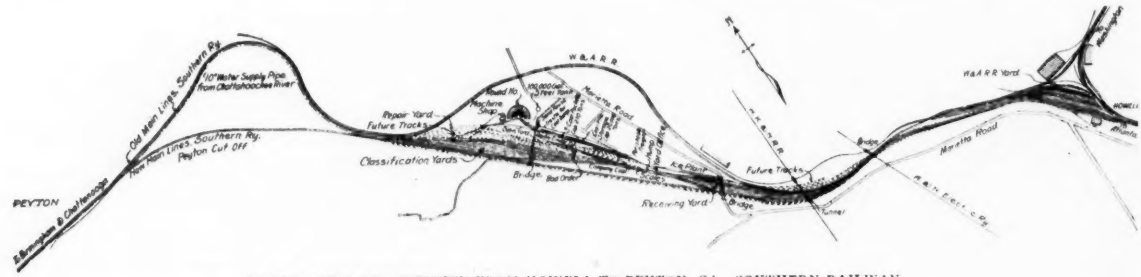
It was decided to build a double hump yard which should serve all the Southern Railway lines entering the city, embracing the Chattanooga and Birmingham roads, from the northwest and west, the Macon road from the southwest and the Columbus road from the south, and providing for the Charlotte main line northeast.

On account, however, of the contour of the country, and the grades descending toward the Chattahoochee river, it was found not practicable to so arrange the yard, but in its place a one hump yard arrangement was substituted, which, while requiring a certain amount of back movement for trains working in one direction, would very well serve the purpose with a minimum amount of switching.

The sketch indicates the arrangement of the yard, which, as will be observed, permits trains routed for Chattanooga and Birmingham to enter the receiving yard at the south end, pass over the hump and be classified in their proper direction.

Trains from Chattanooga and Birmingham, bound for Atlanta, Charlotte or Macon, will leave the main line at the northwest end of the yard, pass between the classification yard and the main track, alongside the hump, and enter the receiving yard on the side nearest the main line. From that point they will be dropped back over the hump to their proper tracks and, when made up, will enter the main line, proceeding on their proper course.

The grade of the receiving yard is about 0.65 per cent descending toward the hump, but rising before reaching



INMAN YARD AND VICINITY FROM HOWELL TO PEYTON, GA., SOUTHERN RAILWAY.

it in order to allow uncoupling; the latter, below the hump, has a grade of 1 per cent, which diminishes to 0.4 per cent through the classification yard, joining the main line at the lower end, the main line being practically of a uniform grade.

In addition to the freight yard, there was built a 30-stall round house, as indicated, with a small machine shop and power house adjoining.

The coaling station, as planned, provides for a coal trestle reached by the ordinary incline approach. The coal is dropped into the pit under the trestle, where there is a storage capacity for about 20,000 tons. A light trestle runs parallel with the coal pile, upon which is operated a locomotive coaling crane, which takes the coal directly from the pit and places it upon the tenders. There are also coal pockets of 300-ton capacity, which will be kept filled and used for coaling engines when the crane is otherwise engaged. The cinder pit will be cleaned by the coaling crane.

The question of water supply being of much importance at this point, it was found necessary to establish an electric plant, taking water from the Chattochoochee river. The electric power for this service is supplied from the power house, adjoining the machine shop, this being located about three miles from the pumps. These pumps are controlled from the power house. On account of the frequent overflow of the river, a pumping pit was located about 400 feet from the river bank.

On the hill, about 40 feet above the round house, is placed a 100,000-gallon capacity steel tank, as indicated, the bottom of the tank being 100 feet above the tracks.

As will be observed, there is a four-track connection between the south end of the new yard and the junction at Howells, where the main lines diverge, one line passing the northeast to Charlotte and Washington, and the other leading to Macon, Columbus and Jacksonville.

There were two or three important streets or roads crossing the site of this yard, which were taken care of by re-erecting light railway bridges which had been released from points on the line, one of the roads being of sufficient importance to require the use of two lines of spans. These bridges rest on concrete piers and abutments, and very well answer the purpose.

The cost of improvements, not including equipment nor the value of the real estate, was $925,000, of which about $300,000 was the cost of grading the site.

Brush Creek Viaduct

I. C. R. R.

THE Brush Creek viaduct is located on the Alabama Western, near Haleyville. This line is a section of the Birmingham extension of the Illinois Central railroad.

The viaduct is 1230 feet 7¼ inches from face to face of parapets, being made up of two 60-foot deck plate girder approaches, ten 75-foot deck plate girder spans and nine towers with 40-foot deck plate girder spans. The approach spans rest on concrete abutments and rocker bents.

The foundation for the towers and rocker bents consists of masonry piers, varying from 6 to 24 feet in depth. The tops of these piers are 5 feet 6 inches square. They are stepped on the outside to provide for masonry extension when the line is double-tracked.

The distance from the base of the rail to masonry varies, the maximum height being 171 feet 2 inches. Included in that, is the height of deck plate girder and tie, being 7 feet 7¼ inches and 10 inches respectively.

The towers are built up of four columns, which are joined by diagonal braces of channels, as shown in the illustrations. The columns are made up of two plates and four angles, which decrease in thickness from the masonry upwards. Two of the angles are riveted to each plate and the plates are spaced 21¼ inches apart and laced with 3 x 2 x ⅜-inch angles. The diagonal braces for the columns of each tower are made up of the same size channels throughout. The towers are constructed in one, two or three sections, depending on the height of column. They are 75 feet 9⅝ inches in width at the bottom and 8 feet at the top. The accompanying illustrations show clearly the method of erection.

BRUSH CREEK VIADUCT, I. C. R. R.

CONSTRUCTION VIEW, SHOWING TRAVELER, BRUSH CREEK VIADUCT

Expansion is allowed for as follows: The 60-foot approach spans are fixed at the rocker bent, as are also the 75-foot spans. At all other points, the 75-foot spans are alternately fixed and loose on each side. The 40-foot spans are fixed at both ends on the columns. The towers are fixed at diagonally opposite corners of the bases, while they are loose to provide for expansion at the others.

In the design of these towers future double-tracking of the line was considered. Thus, by the addition of columns, connected to the present ones by diagonal braces, it will be possible to support additional plate girders on each side at a distance of 8 feet from the center of the present girders.

There were aproximately 1,550 cubic yards of masonry used and the total amount of steel was 1,943 tons.

The viaduct was erected by the Strobel Steel Construction Company. As shown in the illustration, a double trolley traveler was used. The total time was 40 days from beginning the work of erection to the crossing of the first train. The steel was furnished by the McClintock-Marshall Construction Company from its plant at Rankin, Pa.

The viaduct was designed under the supervision of R. E. Gant, bridge engineer, and A. S. Baldwin, chief engineer of the Illinois Central. The field work was in charge of W. F. Gordon, resident engineer of the Alabama Western, and G. A. Butler, masonry inspector. The steel work was under the direct supervision of J. B. Gant, inspector in the bridge department.

The Chicago & Northwestern Railroad will construct a double-tracked steel bridge across the Mississippi river at Clinton, Iowa. This bridge will be built south of and adjoining the present single track bridge, which is to be removed on completion of the new bridge. It will be about 2 miles in length and will cost about $2,000,000. The date of completion is set at February 1, 1910.

Heavy Electric Traction

THIS article is an abstract of a paper on the subject by Mr. E. H. McHenry, vice-president of the New York, New Haven and Hartford Railroad:

On May 7, 1903, an act of Legislature of the state of New York made it compulsory for the roads entering the city of New York over the New York and Harlem R. R. to operate their trains by some motive power other than steam, which did not involve combustion in the motors themselves. As electricity was the only motive power that would meet the requirements of the law in addition to traffic conditions, the New York Central and the N. Y., N. H. & H. R. R. as the roads involved, immediately began preparations for the electrification of their terminals within the city of New York. The adoption of the continuous current system by the New York Central and the complete installation of equipment and operation of terminals by electricity for some months, is a matter of record. In this system there is a high tension transmission of 11,000 volts alternating current from power house to sub-stations, located about every 5 miles, where the voltage is transformed to 666 volts continuous current.

On July 21st, the New York, New Haven and Hartford began the operation of trains out of New York by the alternating current single phase system. This is the first large installation of a system which is generally considered to be the most practical plan for the electrification of steam trunk lines. The system adopted by the N. Y., N. H. & H. is based on the use of alternating current motors, taking current from overhead conductors. The current used is 11,000 volts, 25 cycles, alternating current, and is stepped down by transformers on the locomotives to 560 volts for use at the motors.

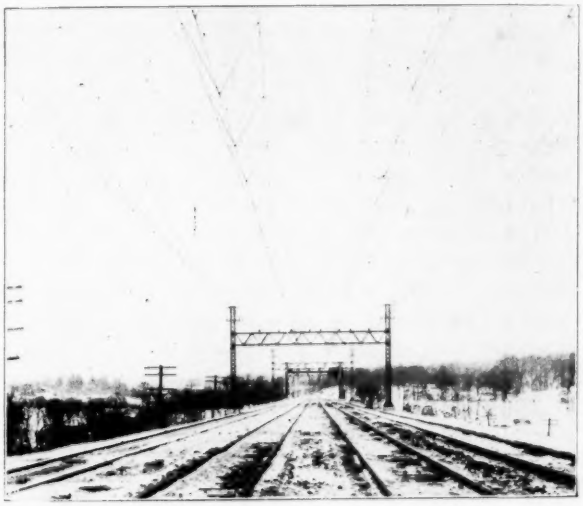
The service began with thirty-five 1,000 horse power locomotives, each capable of pulling a train of 10 coaches at an average speed of 75 miles an hour. The locomotives are of steel construction, 36 ft. 2 ins. over couplers and weigh approximately 90 tons. Current collectors are of the pantagraph type and, for operation on the New

BRUSH CREEK VIADUCT

York Central joint track, third rail contact shoes are provided. The motors are arranged to operate with both alternating and direct current. In order to carry the high pressure conductors safely under all conditions, the catenary system of support, with steel supporting bridges was adopted. Two feeder wires parallel the main conductors and act as auxiliaries in order to feed around any one section in case of accident. The power house for furnishing the electric current for the system is located at Cos Cob, Conn. The generating equipment of the power station consists of three multiple expansion Parsons steam turbines direct connected to three Westinghouse generators of 3,000-kw capacity each. The boiler plant consists of twelve 525-hp. Babcock and Wilcox boilers, equipped with superheaters and mechanical stokers. It will be noted that all the details of the installation are of the most modern and approved type.

OVERHEAD CATENARY CONSTRUCTION.

One of the chief advantages derived from the use of alternating-current is that a high pressure may be

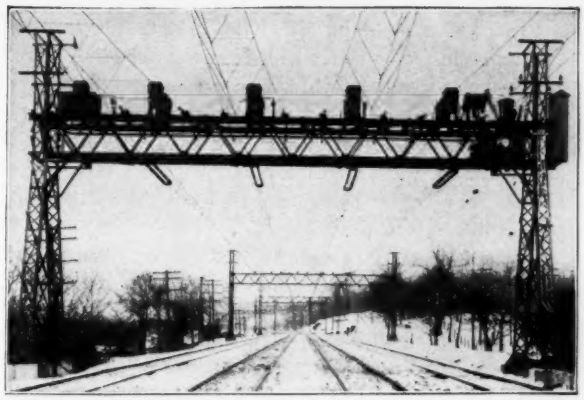


VIEW OF TRACK, SHOWING CATENARY CONSTRUCTION, N. Y., N. H. & H. R. R.

used on the supply system, and in the present instance the potential of the overhead conductor is 11,000 volts. This high pressure renders it necessary to support the conductors over the tracks in a very substantial manner, and, accordingly, the catenary system of support was adopted.

This system in the present instance consists of two steel cables, each having an ultimate strength of 33,800 pounds, supported at intervals by steel bridge structures. A copper conductor or trolley wire is suspended below the two supporting cables by means of hangers placed every ten feet.

Whenever the cables pass over the steel supporting bridges they rest upon massive porcelain insulators, and at intervals heavy bridges are provided against which the cables are anchored by means of specially constructed strain insulators.

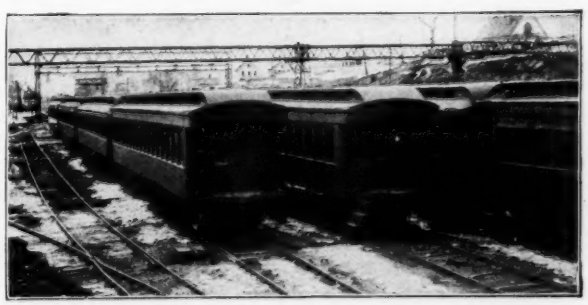


ANCHOR BRIDGE OVER TRACKS ON THE N. Y. N. A. & H. R. R.

The steel supporting bridges are of varying lengths, so as to accommodate 4, 5, 6, or as many as 12 tracks, as the local conditions require, without the necessity of placing posts between tracks. These bridges are of a uniform design and consist of angle iron and lattice bar construction. The intermediate bridges are of course much lighter than the anchor bridges, which are used at intervals of about two miles. The former have side posts of square cross section and comparatively light construction. On the other hand, the anchor bridges have A-shaped posts and are made heavier, in order to withstand the strain of the cables.

The anchor bridges are provided with automatic circuit-breakers by means of which the different sections may be isolated, and also the several parallel tracks separated from one another in case of accident to any one track. The anchor bridges also carry lightning arresters, shunt transformers for operating the circuit-beakers, together with foot walks, hand railings, lighting circuits and the wires and conduit for the auxiliary control circuits.

The main conductors, consisting of standard No. 0000 B. & S. gauge grooved copper, over the running tracks, are paralleled throughout their entire length from Stamford to Woodlawn by two feeder wires. These feeders constitute auxiliaries to the main track conductors and are connected with the latter at each anchor bridge through circuit-breakers. The office of the auxiliary feeders is to provide means for feeding around any one section in case it is cut out of service on account of some accident in that particular section.



SPECIAL BRIDGE OVER YARDS, N. Y., N. H. & H. R. R.

Provision is made on all of the bridges for carrying two separate feeder wires called "power feeders," which are connected to the third phase of the generating system and are used for operating three-phase apparatus at certain intervals along the road. Provision is also made on the bridges for carrying two three-phase circuits, one circuit being supported on the top of each post at the ends of the bridges.

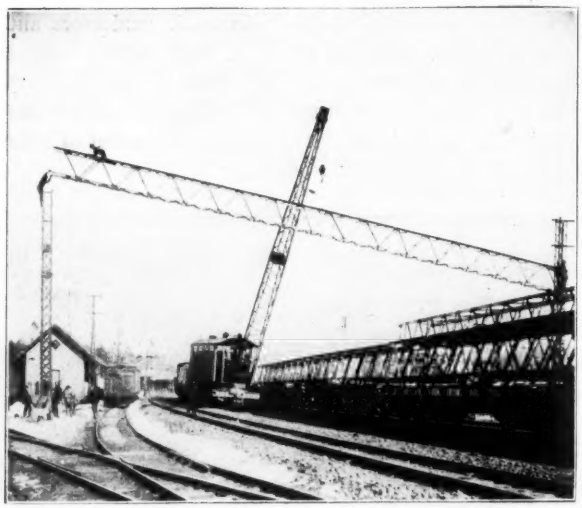
In laying out the bridges for the section from Woodlawn to Stamford, it was found that the sharpest curvature was 3 degrees. As this curvature will permit of stringing trolley wire in straight lines between points of support 150 feet apart without deviating from the center of the track more than 8½ inches on each side, it was decided to place all bridges a fixed distance of 300 feet apart, and on curves to provide guide poles from which pull-over wires are attached and secured to the catenary spans. By this means a minimum amount of overhead wiring was obtained, and the deviation from the center of the track was maintained within safe limits for use in connection with the sliding pantagraph trolleys on the locomotives.

Both rails of all tracks are bonded by means of No. 0000 compressed terminal flexible bonds placed round the fish plates.

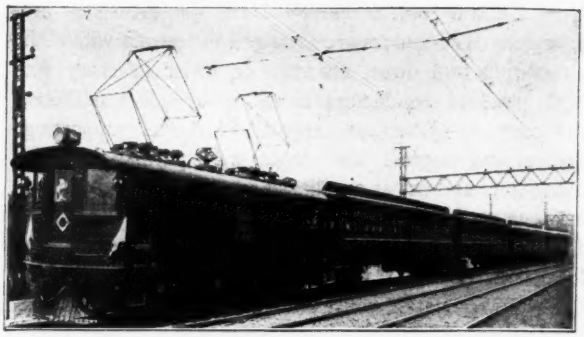
Wherever one track diverges from another a section insulator is inserted in the trolley wire. Insulators are inserted in the catenary cables supporting the diverging wire between parallel tracks.

The diverging trolley wire is connected to the main wire by means of a frog of standard design, and in order to prevent the contact shoes on the locomotive from catching, deflector wires are placed in the angles between the two trolley wires. These deflectors are carried by yokes screwed to the trolley wires and to yokes at the ends fastened to the catenary hangers. These deflectors are raised at each end so that the collector's shoe cannot catch over them.

The insulators which support the catenary cables on



METHOD OF ERECTING INTERMEDIATE BRIDGES AND POSTS, N. Y., N. H. & H. R. R



SINGLE PHASE LOCOMOTIVE AND TRAIN, N. Y., N. H. & H. R. R.

the intermediate bridges consist of heavy porcelain insulators of the skirt type which are 15 ins. in diameter and about 7 ins. high. These insulators are cemented upon short lengths of double extra strong pipe, which in turn is held by means of U-bolts to a cast iron yoke bolted to the upper chords of the truss. The catenary cable rests in a groove in the top of the porcelain and is held by means of a malleable iron clamp fitted with U-bolts and placed one on each side of the insulator. The head of the insulator is conical in shape and is surrounded by means of a split malleable iron clamp and a lead packing.

One notable feature of the construction is the arrangement of the clamp and the collar, which is such that in case of the breakage of the messenger cable on one side of the insulator, the pull of the cable on the other side will cause the clamp to swing downwards, thereby lowering the point of application of the pull of the cable, so that the porcelain is put in compression and there is no tendency to shear off the top of the porcelain as is usually the case with porcelain line insulators. Each porcelain stands a shop test of 55,000 volts assembled.

The insulators which are used for dead-ending the catenary cables at the anchor bridges, are of special construction and are designed to stand a shop test of 50,000 volts and a working load of 20,000 lbs. They consist of a length of 2-in. extra heavy iron pipe, surrounded at its middle point by an iron collar. Outside of this collar along insulating tube, composed of especially hard and reliable insulating material, is pressed. A second collar surrounds this tube, into which a bolt is screwed and to which the turn-buckle of the catenary cable is attached. The entire surface of the insulating tube and the inner and outer collars are then effectively sealed against moisture by means of a high-grade insulating compound applied by means of hydraulic pressure. The insulator thus made up is supported by means of an iron yoke cast iron hooks bolted to the upper chords of the anchor bridge truss. One of these insulators is provided in each catenary cable at each anchor bridge, thereby dividing the road up into separate sections between the anchor bridges.

While definite comparisons of the cost of installations of the continuous and alternating current systems cannot be furnished at the present time, the experience already gained by the New Haven engineers indicates that the cost of the single-phase installation is the cheaper of the

two. This in addition to the higher electrical efficiency, lower fixed charges, maintenance and operating expenses illustrates the advantages of the single-phase alternating system over the continuous current system for trunk line operation.

The determination of the most economical and desirable frequency and voltage of the transmission system involved the consideration of many factors entering into the problem. The choice of frequency was practically fixed by the manufacturing companies within limits of fifteen and twenty-five cycles, and the comparative merits of these two rates only were considered.

The lower frequency afforded a material reduction in weight, size, and cost of motors, a reduction in conductor loses and induction disturbances, together with an increase in the power factor of the motors. Per contra, its adoption would have materially impaired the commercial value of the system as a whole, in restricting or preventing its extension for many other uses incidental to railway operation. The standard power and railway frequency in general use is twenty-five cycles, and as the New Haven Company already owned a number of power houses generating current at this frequency for standard trolley operation, and, in addition, had equipped many of its shops with twenty-five cycle motors, the adoption of fifteen cycles would have required the abandonment of a large amount of standard apparatus, or the interposition of costly and inefficient means of translation. The lighting of stations and other buildings was quite an important factor, as 25 cycles is the lowest frequency at which the carbon filament lamps in general use can be satisfactorily operated. It was also considered desirable to provide for operation in parallel with the 25 cycle generators already adopted by the New York Central Company. The practical effect of a change from 25 to 15 cycle apparatus was thus substantially equivalent to a "break in gauge," and under existing conditions it was decided that the practical commercial value of the higher frequency outweighed the more theoretical merits of the lower one.

Various alternatives were considered before fixing the generating and transmission e. m. f. of the system. It was at first proposed to increase the economical radius of transmission to the utmost by generating current at the highest initial voltage for which generators could be safely designed (about 22,000 volts) and to provide substations at suitable intervals, equipped with static transformers, for supplying current at 3,000-6,000 volts to secondary contact circuits. As the two motors in each electric locomotive truck are permanently connected in series current must be supplied at 560 volts through the transformer forming a part of the locomotive's equipment.

It became evident, however, that a great gain in simplicity would result if the intermediate substations and line transformers could be cut out altogether, and further study demonstrated the possibility of effecting this by reducing the initial e. m. f. to 11,000 volts and raising the ratio of the locomotive transformer to correspond. This was carried into effect with a resulting reduction in capital and operating cost, coupled with an increase of electrical efficiency, which proved most gratifying. Incidentally, the difficulties in designing satisfactory collecting devices were greatly diminished.

The difficult and responsible task of determining and analyzing operating conditions and requirements was assigned to Mr. Calvert Townley, Consulting Engineer, and Mr. William S. Murray, Electrical Engineer, of the N. Y., N. H. & H.

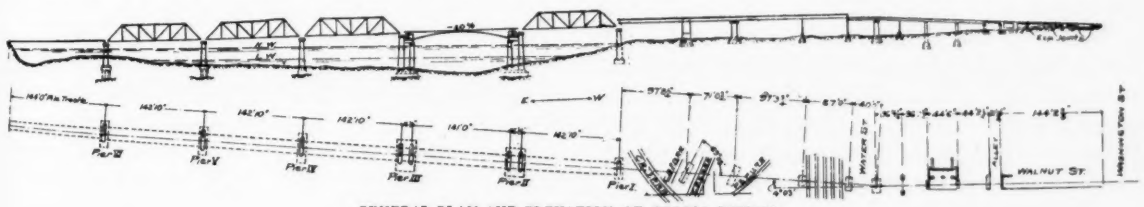
The Westinghouse Electric and Manufacturing Company of Pittsburgh furnished electrical equipment consisting of steam turbines, generators, locomotives, line construction, etc., and Westinghouse, Church, Kerr and Company installed the entire system.

Illinois River Bridge, Peoria, Ill.

ACROSS the Illinois river, there has recently been erected a single track railway bridge. It extends from Walnut street, Peoria, Ill., across to East Peoria. The structure, which is 16 feet in width, consists of a western approach from the Peoria side, about 550 feet in length; one steel truss with clear span of 135 feet 10 inches; one bascule span; three steel trusses, similar to the one mentioned above, and the eastern approach, 144 feet in length.

The Peoria approach consists first of an earth embankment with a concrete masonry retaining wall on one side, extending from the east line of Washington street to an abutment at the west side of the alley next east, as shown in the general plan. The concrete is divided into several panels, giving a neat appearance. The concrete above the foundation blocks and below the copings was proportioned 1:2:5, with stone not to exceed 2 inches in diameter and the concrete in the copings and parapets was 1:2:4, with stone reduced to 1 inch in diameter.

The next section of the structure is a viaduct, of the deck plate girder type, which carries the street railway over a number of railroad tracks. The first 200 feet of



GENERAL PLAN AND ELEVATION OF PEORIA BRIDGE.

ILLINOIS RIVER BRIDGE, PEORIA, ILL.

this viaduct is supported on piers, spaced from 36 feet to 44 feet apart. The remaining 333 feet is supported on piers spaced from 67 to 98 feet apart.

The piers vary in size and construction. Several are foundation piers for steel columns. Others are built up entirely of concrete, reinforced with Johnson bars as shown in the accompanying illustration, which is of the pier at the east side of the alley at the beginning of the viaduct.

The bascule span is the second of the Rall type to be built. It is a double leaf deck bridge, requiring no pit as the grade is high above the water line. The span is 141 feet between supports, the clear channel span being 125 feet.

This type of bridge, when closed, rests upon fixed supports at the piers, the rollers being lifted slightly above the track for this position and relieved of their load. The bridge is supported at its center of gravity by a shaft carrying rollers at its extreme ends. The bridge, in rotating around this shaft, is made to roll backwards by means of a pair of swing struts. These struts are connected to the pier at one end and to the main girders at the other, and describe a motion such that, as the main girders revolve, they at the same time are rolled back.

The advantage of this type of bascule bridge may be summarized as follows: For the bridge closed the length of span is a minimum and equal to the distance center to center of river piers; the length of travel of the bridge is a minimum, being just sufficient so that the tail part containing the counterweight will clear the river pier when the bridge is fully open; the shop work on the bridge proper is simple and of a character that can readily be turned out by a bridge shop having ordinary facilities; the wheels or rollers upon which the bridge moves, are solid steel castings, having smooth treads, they may be made of any proportions that will be suitable, they have no rivets to give out and there is nothing to bind, the motion being smooth and noiseless; the track girders in the case of the Peoria bridge are double 24-inch I-beams with flange plates on top and bottom and track plates riveted to the top; should it be desirable to remove or repair the wheels this can readily be done, as the bridge in a closed position does not bear upon the wheels, and should it be desirable to repair or remove the track girders, this too can readily be done, for the same reason, without disturbing traffic over the bridge.

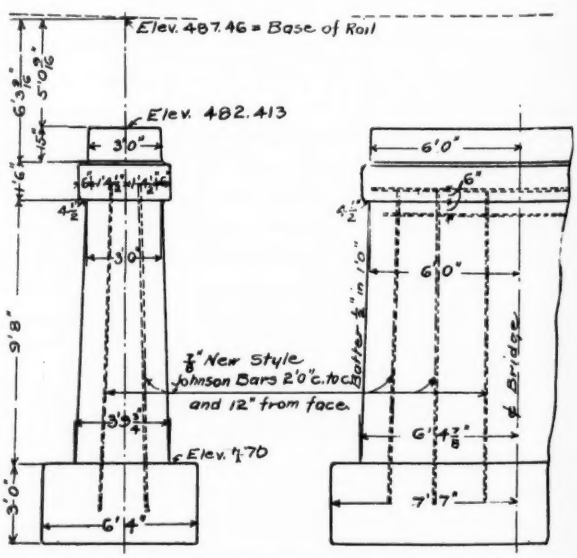
This bridge is opened and closed in ¾ of a minute. Including insertion of tail lock and rail lock, for both leaves, a complete operation requires two minutes time.

The electrical equipment includes one 25-h. p. electric motor for each leaf of the bascule span. These motors are of the enclosed type and are wound for 500-volt direct current. There is a 2-h. p. motor, which provides for the center lock. The electrical equipment is designed for controlling both leaves from one operator's house. There is an indicator in the operator's house, showing the position of each leaf at all times during its motion. An automatic cut-off opens the motor circuit when the bridge has reached its maximum opening.

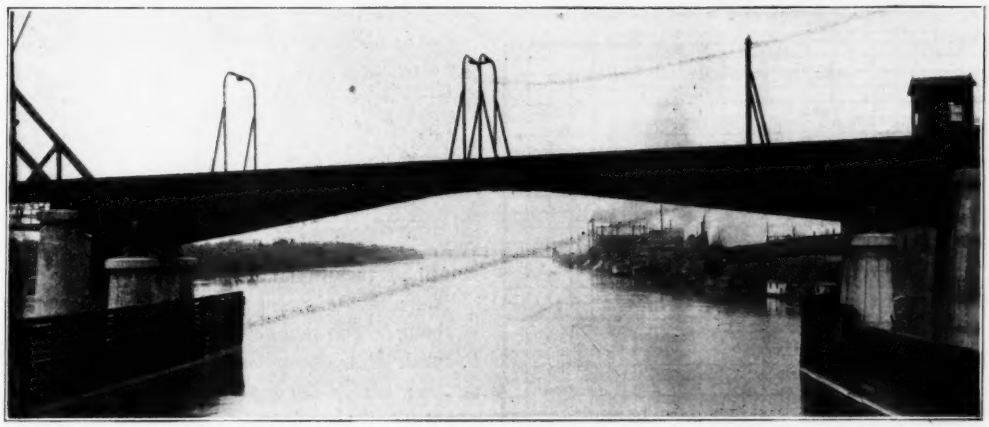
The operating machinery is below the deck, nothing showing above the deck except the operating house and the trolley poles and lines.

The bascule span was designed under the Rall patents by the Strobel Steel Constructing Company, who also erected the superstructure. Four additional bridges of the Rall type, but "through" instead of "deck," and without pits, are now under construction by the Strobel Steel Construction Company at Indiana Harbor, Ind. Two of these bridges are for the Lake Shore & Michigan Southern railway, one for the Baltimore & Ohio railroad, and one for the Pennsylvania lines. They are single leaf double track bridges of 86 ft. span between supports. Bids were submitted for these bridges in a lump sum and the contract was awarded to the lowest bidder.

The structure was designed for a dead load, consisting of its own weight and a live load consisting of a continuously moving train of 75-ton cars, having a load of 37,500 pounds on each of four axles. The cars were taken as 40 feet long, the distance between the axles of



PLAN SHOWING REINFORCEMENT OF CONCRETE PIER, ILLINOIS RIVER BRIDGE.



BASCULE SPAN, ILLINOIS RIVER BRIDGE.

each truck as 6 feet and the distance from center to center of trucks as 25 feet. The wind pressure, assumed as acting longitudinally in either direction, was taken as 30 pounds per sq. ft. on the loaded structure, 50 pounds on the unloaded and 20 pounds on floor of bascule span when bridge is open, the machinery being designed to operate safely under this pressure.

The engineer for the Illinois Traction Company was Mr. Ralph Modjeski, who designed the structure with the exception of the bascule span.

Holding Power of Railroad Spikes

THIS article is an abstract of Bulletin No. 6 of the University of Illinois Engineering Experiment Station. The tests were made by Mr. Roy I. Webber, C. E., instructor in civil engineering.

The experiments were divided in two distinct groups, as follows: First, the determination of the resistance to direct pull of several forms of spikes; and, second, an investigation of the resistance to lateral thrust.

RESISTANCE TO DIRECT PULL.

A Riehle 100,000-pound testing machine was used in making the experiments on resistance to direct pull. The pulling device for ordinary spikes was a Verona spike-puller, threaded into a piece of steel gripped between the lower jaws, of the machine. For screw spikes the pulling device was of similar pattern but designed especially for those tests. The distance moved through the lower head of the machine was measured directly by a scale graduated to one-sixteenth of an inch. A 500-pound load was applied before any records were taken to insure a good bearing of the tie. The machine was geared to move at the rate of five-eighths of an inch per minute, allowing ample time for balancing the machine and for taking readings. Readings were usually taken when the tower head had moved through ⅛, ¼, ½ and ¾ inches and also at the point of maximum resistance.

HOLDING POWER OF ORDINARY SPIKES.

The ordinary spikes and the ties were supplied by various railroads and manufacturing companies. The spikes were 5½ to 6 inches long, they had an area of 0.316 to 0.372 square inches and they had a smooth surface with chisel, blunt or sharp points. They were driven to a depth of 5 inches.

The maximum holding power of spikes in untreated ties was satisfactory for white oak, elm and beech, but was rather low for chestnut and loblolly pine. The maximum resistance occurred when the spike was pulled from 3-16 to 3-8 of an inch and for the first three, mentioned above, exceeded 7,290 pounds.

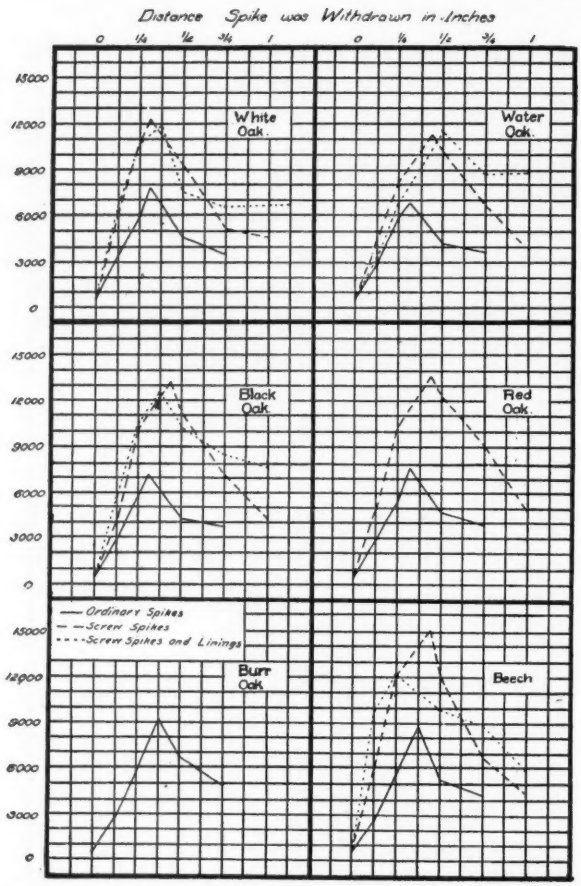
A comparison of tests with spikes in treated timbers with those in untreated white oak show that the initial resistance of the white oak is higher than any of the other woods except one, while the resistance at ¼ of an inch in white oak is less than in any of the other woods except one. Considering the uniformity of the results with a pull of ¼ inch, there does not seem to be much room for discrimination between the various treated timbers which were here used.

A comparison of several timbers, treated and untreated, indicate an increased resistance for the treated timber. The causes are as follows: First, the presence of the preservative in the cells, thus reducing the space into which the fibres can crowd as the spike is withdrawn; and, second, the hardening of the fibres by the steaming, preparatory to treatment, which renders them less pliable.

If a rating of the preservatives in relation to their effect on the holding power was made, it would be about as follows: First, creosote; second, zinc-creosote, and, third, zinc-tannin. There are, however, too many uncertain quantities to make such a rating reliable.

That the holding power will be increased with the size of the rod, or spike, was determined by experiments with plain square rods in beech timber. It is thought, however, that it is not expedient to use spikes larger than ¾ inch, unless holes are bored for them.

The effect of the point of the spike on the holding power was determined. The blunt-pointed and bevel-pointed are higher in holding power than the chisel-pointed, the blunt-pointed being first in point of efficiency.



CURVES SHOWING RESISTANCE TO WITHDRAWAL OF THE SPIKE FROM THE TIE.

The effect of bored holes on the holding power of spikes is to increase the efficiency for a pull of ¼-inch or less for all timbers. The maximum resistance, however, is lower for spikes driven into bored holes.

Re-driving the spikes reduces the holding power from 20 to 40 per cent of the original. The practice is resorted to in order to lengthen the life of the tie. It cannot be condemned as long as the holding power is not excessively reduced by a too great enlargement of the hole.

HOLDING POWER OF SCREW SPIKES WITHOUT LININGS.

The tests were similar to those conducted with ordinary spikes. The shank or threaded portion of the spike was usually ⅞ inch in diameter and about one inch of the upper portion of the core tapered from the diameter of the core to that of the shank. There was a tight fit between the wood and the spike, the bored hole not being reamed. In practice, tight contact is gained by the head of the spike bearing against the base of the rail. The spike was driven by means of a wrench, the thread cutting its own path.

The resistance of screw and ordinary spikes varies directly with the depth of penetration. The accompanying diagram gives a comparison for screw and ordinary spikes.

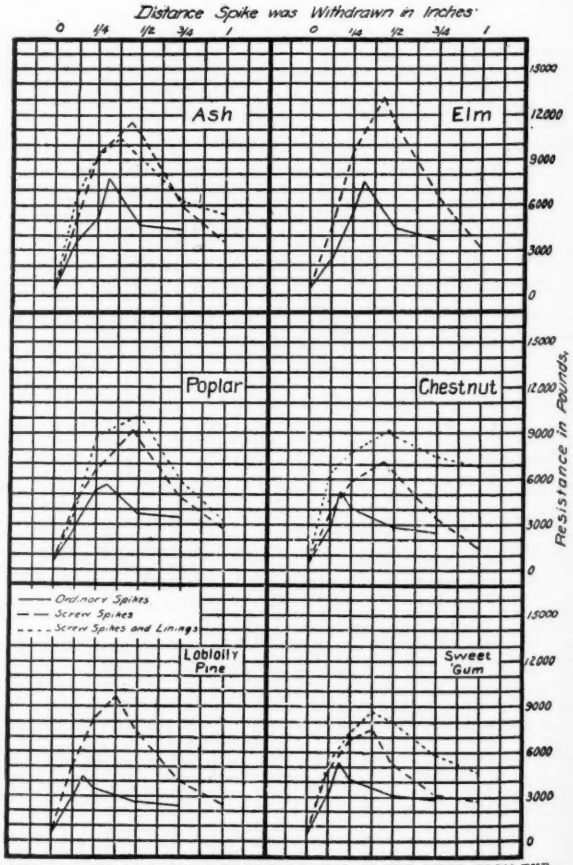
The holding power of the screw spike is always greater than that of the ordinary spike, varying in amount in the several timbers. The gain in holding power in soft woods is about 98 per cent and in hard woods about 76 per cent for a pull of ¼ inch. The screw might be said to have twice the efficiency of the ordinary spike.

The effect of certain details of the screw spike is to increase holding power. Where the screw spike has been more extensively used it has been perfected in several ways. The details include the diameter of the core, the projection and pitch of the thread and the length of the thread.

The ultimate strength of the soft steel of the spike is about 66,000 pounds per square inch, giving a tensile strength of 24,000 pounds. The ultimate compressive resistance across the grain of well-seasoned white oak is about 4,000 pounds per square inch, which is increased about 40 per cent on account of the thread compacting the fibres. Therefore, taking 5,600 pounds as the ultimate compressive strength of compacted white oak, and taking 17¾ inches and ⅛ inch respectively as the length and projection of the thread on the 5-inch spike, the theoretical resistance, without making an allowance for frictional resistance, resistance between the core of the spike and the wood, would be

$$5600 \times 17\tfrac{3}{4} \times \tfrac{1}{8} = 12{,}430 \text{ pounds.}$$

The average actual resistance obtained in white oak ties by test was 12,630 pounds. The tensile strength of the screw spike is about 12,000 pounds greater than the maximum resistance of white oak, which difference is



CURVES SHOWING RESISTANCE TO WITHDRAWAL OF THE SPIKE FROM THE TIE.

greater than necessary and indicates an uneconomical use of metal in the spike. Since the ties tested are representative of American practice, there is no apparent reason for not having the ultimate strength of the two materials in contact more nearly equal than at present, and by some slight change in the detail of the spike this could readily be accomplished. Three ways in which the ultimate strength of the materials may be made more nearly equal are: First, increase in length of threaded portion; second, increase in projection of thread, the length and the diameter of he core remaining the same; and third, increase in projection of thread at the expense of the core, the length remaining the same. The pitch is assumed to be ½ inch in all cases, since it has been found in practice that this pitch gives better results than either a greater or smaller pitch.*

1.—The length of the thread on the 5-inch spike is 17¾ inches and the width is ⅛ of an inch; therfore, the bearing area is 2.22 square inches. If the spike is made 6 inches long two convolutions of the thread will be added, the bearing area will become 2.71 square inches, and the holding power will be increased from 12,630 pounds to 15,180 pounds. This leaves a difference of only 8,900 pounds between the ultimate strength of the wood and that of the spike.

2.—If the length of the spike and the diameter of the core are not changed, and if the projection of the thread is increased 1-32 of an inch, the total resistance would amount to 15,510 pounds, leaving the ultimate strength of the spike only 8,500 pounds greater than that of the wood.

3.—If the length of the threaded portion of the spike remains unchanged, and if the projection of the thread is increased 1-32 of an inch at the expense of the core, the maximum resistance would amount to 15,510 pounds, while the ultimate strength of the spike would be reduced to 20,200 pounds.

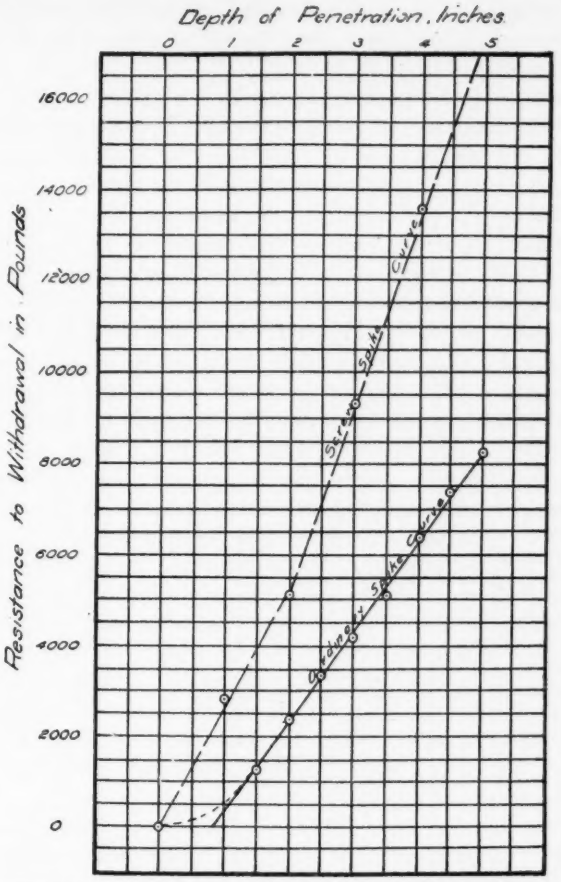
The diameter of the shank of the spike would have to be increased with some of the changes in the detail of the lower portion, and when the resistance to lateral displacement is taken into account, we see that this change also would be beneficial.

The conclusion is that the screw spike in its present form is about twice as efficient as the ordinary spike, and that the efficiency could be increased by some slight change in the detail of the screw spike.

HOLDING POWER OF SCREW SPIKES WITH HELICAL LININGS.

The lining is a foreign invention which is only used experimentally on American railroads. The linings, together with a set of tools for inserting them in the tie, were furnished by Mr. Robert Trimble, Chief Engineer Maintenance of Way, Pennsylvania Lines.

The linings, made by Mr. J. Throllier of Paris, France, were described by him as being 0.33 x 0.17 inches in section and as being of the P. M. class or small sized. They were 4 inches long, with ½-inch pitch. The total



CURVES ILLUSTRATING RESISTANCE TO WITHDRAWAL OF THE SCREW AND ORDINARY SPIKES FOR VARIOUS DEPTHS OF PENETRATION.

diameter was 1 15-16 inches, the diameter inside the spiral band slightly over 11-16 inch, and the thickness and width of the metal band ⅛ and ¾-inch respectively.

The method of fixing the lining in place was as follows: A hole having the same diameter as the core of the spike was bored in the tie, the hole was tapped and the lining inserted by means of special tools designed for the purpose. The spike was then inserted in the usual manner.

The results of the tests are given in the accompanying diagrams. In hard woods the resistances for ⅛-inch pull are greater for the spike and lining and for the bare screw spike, but less for pulls exceeding ⅛-inch. In soft woods, excepting sweet gum, the spike and lining gave greater resistances.

The principal claims for the P. M. lining are that it can be placed on the track without removing either the rail or the tie, and that it forms an advantageous substitute for the square wooden dowel used on some railways.

The author claims that the use of the small lining is impracticable for the following reasons: First, it is designed to be put in place with the tie in the track; second, the lining cannot always be inserted into the wood to its full length by means of hand tools, even with utmost precaution; third, at best the holding power is not increased to any marked degree over that of the naked

* Bulletin No. 50, U. S. Department of Agriculture.

screw spike, and fourth, the labor involved is more than double that required to drive the naked screw spike, and the cost is increased.

RESISTANCE TO LATERAL DISPLACEMENT.

The railroad spike is subjected not only to a direct pull by the undulation of the rail, but also to a horizontal thrust due to the lateral movement of the rail. On roads having a large amount of curvature the lateral resistance is of more importance than that of direct pull.

To determine the amount of the resistance to lateral displacement which is developed by various forms of spikes, the writer made a series of tests in which the lateral thrust was produced by the blows of a heavy hammer. The hammer consisted of a cast-iron weight suspended by a wooden rod from the joists of the floor above. Fastened to the joists were metal strips upon which the knife edges of the rocking arm rested. These strips were 6 feet long, and were notched along the entire upper edge to permit the placing of the rocking arm in different positions. The length of the suspending rod was 9 feet.

The weight of the hammer was 100 pounds and the distance through which it was allowed to fall was 1½ feet, so that the amount of the impact for each blow was 150 ft.-lb. The hammer delivered its blow on the end of a tool-steel bar which projected beyond the end of the tie, the other end of the bar being shaped to fit under the head of the spike.

The spikes used in this series of tests were 9-16 inch and ⅝ inch ordinary spikes and screw spikes. Each spike was subjected to five blows and the displacement produced by each blow was carefully measured. Usually four or five spikes of each kind were tested, but when there was much lack of uniformity in the results a larger number were tested.

All of the spikes were bent to a curve, the central point of which was about 1½ inches below the surface of the tie. The ordinary spikes were pulled from the tie a short distance, but the thread of the screw spikes gripped the wood so as to prevent the spike from being pulled out even a perceptible amount.

For ordinary spikes the average total movement of the ⅝ inch spikes in the first seven timbers was 0.65 inch, and that of the 9/16 inch spikes was 0.75 inch. In the last four timbers the average total movement of the ⅝ inch spikes was 0.74 inch, and that of the 9/16 inch spikes was 0.94 inch

The total deflection of the 9/16 inch spikes was usually sufficient to allow a rail to clear the head of the spike if it were overturned. The corresponding movement of the ⅝ spikes was not usually sufficient to allow a like clearance, although it was considerably more than would be allowed in practice.

The first blow is of more importance than the succeeding blows in testing the efficiency of a spike. While the distances through which the different sized spikes were deflected by the first blow differ but a small amount, this difference is sufficient to show that the deflection is less for the ⅝ inch spikes than for the 9/16 inch.

These results, together with the fact that the ⅝ inch spikes were bent less by the impact that the 9/16 inch spikes, indicate that the ⅝ inch spike is more efficient in resisting lateral displacement than the 9/16 inch spike.

The method of determining the lateral resistance of screw spikes was the same as that used for ordinary spikes. The screw spikes used were all practically alike except that they were of various lengths. In making the tests the spikes were used indiscriminately, but since they were not all of the same length some tests were made to determine the effect of impact upon spikes which were driven into the tie to different depths. The spikes used for the latter tests were all of the same make, and were cut to lengths of 3, 3½, 4, 4½ and 5 inches, and were all driven into a single kind of timber. While the results for the 4 and 4½-inch spikes are the same, the averages show that the amount of the lateral movement decreases as the depth of penetration increases. Also, the difference between the deflections of the 4, 4½, and 5-inch spikes is practically negligible, but for shorter lengths the difference in the deflections becomes greater.

The average total deflection of the screw spike in the first seven timbers was 0.50 inch, which is 0.15 inch less than that of the ⅝ inch ordinary spike, 0.25 inch less than that of the 9/16 inch ordinary spike. In the last four kinds of timber the average total deflection of the screw spike was 0.70 inch, which is practically the same as that of the ⅝-inch ordinary spike, but which is 0.24 inch less than that of the 9/16-inch common spike. The results show that the screw spike is superior to the 9/16-inch ordinary spike in all but two kinds of timber, and that the screw spike has a higher efficiency than the ⅝-inch ordinary spike in all but three kinds of timber.

The results show that the ordinary spike was usually displaced more than the screw spike by each blow. This should be expected since the common spike was smaller in cross section than the screw spike, and also since the latter had better bond with the wood. While the use of the screw spike is recommended to the American railroads, it is thought that the practice of Bavarian railroads could be followed to advantage. These roads have adopted the use of the screw spike on the gage side of the rail to resist overturning, but use two square spikes on the outside to resist lateral movement. This practice has been found to give very beneficial results. The figures show that the lateral resistance of two ordinary spikes is considerably more than that of one screw spike, and therefore if two spikes are considered as resisting the impact instead of one, the results will be in favor of the ordinary spikes. Not only is this true, but the first cost for spikes would be reduced, since the screw spike costs about four cents at the present time, whereas the ordinary spike costs much less. The maintenance cost of either form of spike is almost negligible.

SUMMARY OF RESULTS.

1.—The maximum resistance to direct pull varies from 6,000 to 14,000 pounds for screw spikes, from 3,000 to 8,000 pounds for ordinary spikes when driven into un-

treated timbers, and from 4,000 to 9,000 pounds for ordinary spikes when driven into treated timbers.

2.—The direct pull required to withdraw ordinary spikes ⅛-inch varies from 2,000 to 3,500 pounds for untreated timbers, and from 2,500 to 3,500 pounds for treated timbers.

3.—The direct pull required to withdraw ordinary spikes ¼-inch varies from 3,000 to 5,400 pounds for untreated timbers and from 3,800 to 5,900 pounds for treated timbers.

4.—Timbers having loose fiber structures have lower resistances to direct pull than timbers having compact fiber structures.

5.—The amount of withdrawal which must occur for ordinary spikes to develop the maximum resistance is less for soft woods than for hard woods.

6.—Spikes driven into treated timber offer a greater resistance to direct pull than spikes in untreated timbers, and the difference between this resistance for treated and untreated timbers is greater for soft woods than for hard woods.

7.—The difference in the resistance to direct pull for the different sized spikes in use (9-16 inch, 19-32 inch, and ⅝-inch) is very small.

8.—The resistance of ordinary spikes to direct pull varies directly as the depth of penetration, neglecting the tapering point.

9.—Blunt-pointed and bevel-pointed spikes have a slightly greater resistance to direct pull than chisel-pointed spikes.

10.—For withdrawals less than ¼ inch, ordinary spikes which are driven into bored holes have a little greater resistance to direct pull than spikes driven in the ordinary way.

11.—The resistance to direct pull for re-driven spikes is from 60 to 80 per cent of the resistance of newly driven spikes.

12.—The efficiency of screw spikes to resist withdrawal is nearly twice as great as that of common spikes.

13.—The resistance of ⅝-inch spikes to lateral displacement is slightly greater than that of 9-16-inch spikes.

14.—The resistance to lateral displacement increases with the depth of penetration, but the increase is negligible for depths of penetration greater than 4 inches.

15.—Screw spikes are more efficient than ordinary spikes in resisting lateral displacement.

Prices on Track Materials, F. O. B. Chicago

TRACK SUPPLIES.

Steel Rail, 60 lbs. and over. .....$28.00 per gross ton
Steel Rail, 30 to 45 lbs..... 34.00 per gross ton
Steel Rail, 25 lbs.....35.00 per gross ton
Steel Rail, 20 lbs.....36.00 per gross ton
Steel Rail, 16 lbs..... 37.00 per gross ton
Steel Rail, 12 lbs.....38.00 per gross ton
Ties, 6x8x8 oak, 1st grade.....75 to 77c each
Ties, 6x8x8 oak, 2d grade.....67c cash
Switch Ties.....$30.00 to $35.00 M. ft.

Angle bars, accompanying rail orders, 1907 delivery, 1.65c.; car lots, 1.75c. to 1.85c.; spikes, 2.20 to 2.30c., according to delivery; track bolts, 2.65c. to 2.75c., base, square nuts, and 2.80c. to 2.90c., base, hexagon nuts. The store prices on track supplies range from 0.15c. to 0.20c. above mill prices. Switch set per turn out, 60-lb. rail, $75 to $100.

OLD MATERIAL.

	Per Gr.	Per Ton
Old Steel Rails, rerolling.....	$16.75 to	$17.25
Old Steel Rails, less than 3 ft.....	17.00 to	18.00
Old Iron Rails.....	20.50 to	21.00

SHEET STEEL.

It is quoted for future delivery:

Tank plate, ¼-in. and heavier, wider than 6¼ and up to 100 in. wide, inclusive, car lots, Chicago, 1.88c., to 2.08c.; 3-16 in., 1.98c. to 2.18c.; Nos. 7 and 8 gauge, 2.03c. to 2.23c.; No. 9, 2.13c. to 2.33c. Flange quality, in widths up to 100 in., 1.98c. to 2.08c., base for ¼-in. and heavier, with the same advance for lighter weights; Sketch Plates, Tank quality, 1.98c to 2.18c.; Flange quality, 2.08c. Store prices on Plates are as follows: Tank Plate, ¼-in. and heavier, up to 72 in. wide, 2.20c. to 2.30c; from 72 to 96 in. wide, 2.30c. to 2.40c.; 3/16 in., up to 60 in., wide, 2.30c. to 2.40c.; 72 in. wide, 2.50c. to 2.65c.; No. 8 up to 60 in. wide, 2.35c. to 2.45c.; Flange and Head quality, 0.25c, extra.

STRUCTURAL STEEL SHAPES.

Store quotations are unchanged at 2.05c. to 2.10c., and mill prices are as follows: Beams and Channels, 3 to 15 in., inclusive, 1.88c.; Angles, 3 to 6 in., ¼-in. and heavier, 1.88c.; larger than 6 in. on one or both legs, 1.98c.; Beams, larger than 15 in. 1.98c.; Zees, 3 in. and over, 1.88c.; Tees, 3 in. and over, 1.93c., in addition to the usual extras for cutting to extra lengths, punching, coping, bending and other shop work.

CAST IRON PIPE.

Quotations per net ton on Water Pipe, 4 in., $38 to $39; 6 to 12 in., $37 to $38; over 16 in., $36 to $37; with $1 per ton extra for gas pipe.

CEMENT.

Good grade Portland Cement, car lots....$2.00 per bbl.*

* (Four sacks per bbl. credited 10c. each when returned in good condition.)

SAND.

Bank sand, car lot.....$0.55 per yd
Torpedo sand, car lot..... 1.15 per yd.

CRUSHED STONE GRAVEL.

Crushed limestone, car lot.....$1.05 per yd.
Crushed gravel, car lot ..... 1.00 per yd.

Personals

Mr. E. E. Roos has been appointed roadmaster of the Pecos & Northern Texas at Canyon City, Tex.

Mr. E. J. Govern has resigned as assistant engineer of bridges of the Buffalo Rochester & Pittsburg.

Mr. C. M. Colburne has been appointed chief engineer of the Manitoulin & North Shore, with headquarters at Sault Ste. Marie, Ont.

Mr. A. C. Brower has been appointed division engi-

neer of the Missouri Pacific at Wichita, Kan., in place of Mr. E. C. Welch, transferred.

Mr. J. A. Wright has been appointed division engineer of the St. Louis Iron Mountain & Southern at Ferriday, La., in place of Mr. J. A. Simmons, resigned.

Mr. W. D. Wheeler, division engineer of the Minneapolis & St. Louis, has been appointed chief engineer, with headquarters at Minneapolis, Minn., to succeed Mr. H. G. Kelley, resigned.

Mr. E. B. Carter has resigned as general roadmaster of the Florida East Coast to become connected with the U. J. White Company in the development of the Haw Creek properties, located near Dupont, Fla.

Mr. Isham Randolph, chief engineer of the Sanitary District of Chicago for the past 14 years, has resigned and will engage in private practice as consulting engineer. He is succeeded by Mr. George M. Wisner.

Mr. William Graham, who recently resigned as assistant engineer of bridges and buildings of the Baltimore & Ohio, has accepted a similar position with the New York New Haven & Hartford, with headquarters at New Haven, Conn.

Mr. H. M. Hensen, heretofore supervisor of bridges and buildings of the Denver, Kansas & Gulf, has been appointed superintendent of bridges and buildings of the Colorado Southern New Orleans & Pacific, with headquarters at Beaumont, Tex.

Mr. G. P. De Wolf, superintendent of terminals of the National of Mexico, has been appointed assistant chief engineer, of the Mexican International, with office at Ciudad Porfirio Diaz, Coahuila, Mex., to succeed Mr. C. J. Carroll, resigned.

Mr. John Schimmel, Jr., has been appointed supervisor of the Pennsylvania Railroad at Reading, Pa., in place of Mr. P. S. Mitchell, furloughed. Mr. C. A. Pfalzgraff has been appointed supervisor at Olean, N. Y., in place of Mr. Schimmel, Jr. Mr. Norman B. Pitcairn succeeds Mr. Pfalzgraff as assistant supervisor at Altoona, Pa.

Mr. A. E. Hess, chief engineer of the Georgia & Florida, with headquarters at Augusta, Ga., has resigned to become connected with the Pensacola Alabama & Northern.

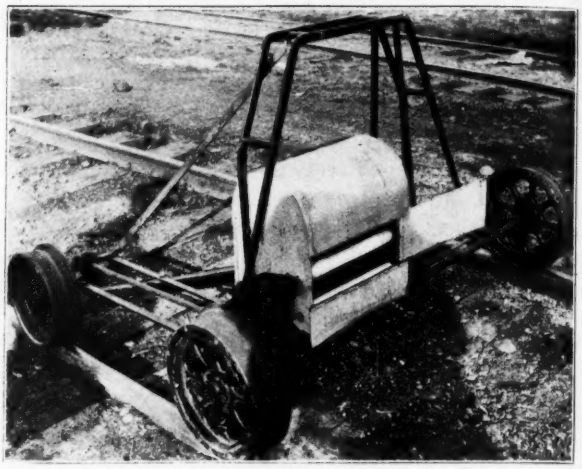
Trade Notes

The D. F. Holman Railway Tracklayer Company of Chicago has recently installed one of its Standard tracklayers on the Canadian Pacific Railway near Parry Sound, Ont., and has shipped another to Katalla, Alaska, for use on the Copper River & North western Railway. An illustrated description of this machine appeared in the February, 1907, issue of this paper.

The Tennessee Construction Co., Chattanooga, Tenn., has been incorporated to build bridges, railroads, gas and electric works, etc. The incorporators are D. J. F. Strother, L. C. Anderson, E. P. Rucker, W. W. Hughes and W. R. Simmons.

The Trenton & Atlantic Construction Co., Trenton, N. J., has been incorporated to construct steam and electric railroads. The incorporators are J. Ridgwot Fell, Trenton, N. J.; L. Warren Hohman, Lakewood, N. J.; and Albert E. Vanderbilt, Princeton, N. J.

Calumet Engineering Works, Chicago, has been awarded the contract for the bridge machinery of the bascule bridge, which is to be constructed for the Chicago & Northwestern across the Chicago river at Kinzie street.



FRONT VIEW SHOWING ARRANGEMENT OF COILS IN WATER-TIGHT BOX, AUTOMATIC TRACK INSPECTOR.

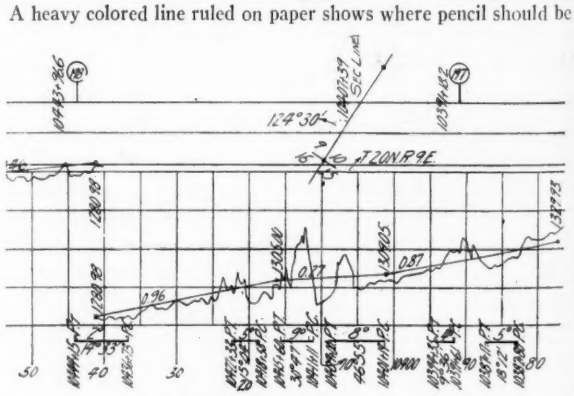
Lemington Manufacturing & Construction Company, Pittsburg, Pa., which was recently organized with a capital stock of $100,000, has purchased a site on which to erect a manufacturing plant. This company has taken over all the rights, patents, etc., of the David C. Creese railway track mover, a device for the quick shifting of railroad tracks to a new position or alignment. R. H. Jackson is president of the Lemington Manufacturing & Construction Company.

The Automatic Track Inspector

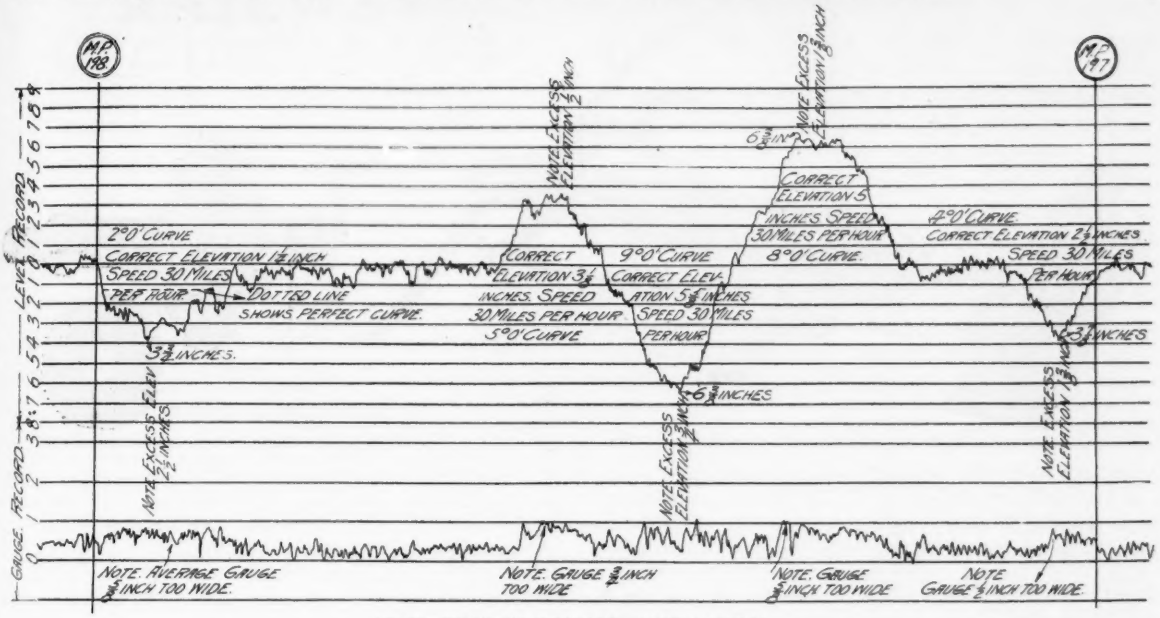
The inventors undertook to build a machine that would make a tracing on a continuous strip of paper by means of pencils, moved by the actual condition of track to show the width of gauge, the amount of elevation on curves, the conditions of spirals on curves and to show whether tangents are level or not. How well they have succeeded can be judged by an examination of the illustrations which are reproductions of the original tracings. The photographs are of the first machine constructed, which is also the one that made the accompanying tracings.

The driving gear moves the paper over the driving roll at the rate of 26 inches of paper to a mile of track. The pendulum moves to right or left as the wheel on either side goes higher than the other, thus moving the pencil to right or left. The paper has a heavily ruled line upon which the pencil follows when the track is perfectly level.

The gauge is obtained by using two pieces of tubing for an axle, one piece of tubing being large enough to allow a smaller one to slip inside of the other. Inside the large tube is placed a graduated spring which always keeps the wheel flanges tight against the rail. A rod attached to the loose end of the axle carries the pencil which comes in contact with the paper and makes every change. A heavy colored line ruled on paper shows where pencil should be



PROFILE OF TRACK FOR WHICH RECORD IS SHOWN, AUTOMATIC TRACK INSPECTOR.


M.P. 198
M.P. 197
LEVEL RECORD 1 2 3 4 5 6 7 8
GAUGE RECORD 0 1 2 3 4 5 6 7 8
2°0' CURVE
CORRECT ELEVATION 1½ INCH
SPEED 30 MILES PER HOUR
DOTTED LINE SHOWS PERFECT CURVE.
3½ INCHES.
NOTE EXCESS ELEV. 2½ INCHES
NOTE EXCESS ELEVATION ½ INCH
CORRECT ELEVATION 3¾ INCHES. SPEED 30 MILES PER HOUR
5°0' CURVE
9°0' CURVE
CORRECT ELEVATION 5⅝ INCHES SPEED 30 MILES PER HOUR
6⅝ INCHES
NOTE EXCESS ELEVATION ⅜ INCH
6⅝ INCHES
NOTE EXCESS ELEVATION ⅜ INCH
CORRECT ELEVATION 5 INCHES SPEED 30 MILES PER HOUR
8°0' CURVE
4°0' CURVE
CORRECT ELEVATION 2¾ INCHES
SPEED 30 MILES PER HOUR
2¾ INCHES
NOTE EXCESS ELEVATION ¼ INCH
NOTE. AVERAGE GAUGE ¾ INCH TOO WIDE.
NOTE. GAUGE ¾ INCH TOO WIDE
NOTE. GAUGE ¾ INCH TOO WIDE
NOTE GAUGE ½ INCH TOO WIDE.

AUTOMATIC TRACK INSPECTOR—SAMPLE RECORD.

at standard gauge. The distance that the pencil moves from this line, shows how much too wide or narrow gauge is at any point.

The front view of the machine, shows the arrangement of rolls in the water tight box. This box is made so that machine can be used in any kind of weather. One roll holds the paper before it passes over the driving roll under the pencils, while the other is the receiving roll which winds the paper up automatically after it is printed. The rolls on the machine, shown in the illustrations, hold sufficient paper to take a tracing over 20 miles of track and can be arranged to hold sufficient paper to trace 50 or 100 miles, as desired. The paper is ruled lengthwise, the lines being one-fourth inch apart, so that track conditions can be measured at a glance instead of using a rule.

The track inspector is operated by attaching it to a hand-car, velocipede or inspection car. It can be run at any speed, not exceeding 12 miles an hour. The machine weighs 200 pounds.

REAR VIEW SHOWING DRIVING GEAR AND PENCILS MAKING TRACING ON ROLL, AUTOMATIC TRACK INSPECTOR.

This machine has been used successfully over 100 miles of railroad. Roadmasters, who have tested the machine have recommended it highly for accuracy and economy in track supervision.

Some results, which are obtained by using the automatic track inspector, are outlined as follows:

1.—It will register accurately the relative position of one rail to the other, that is it will show how much too wide or narrow the gauge is. This is important when we note how many accidents are caused by spreading rails. It also shows the amount of elevation on curves and shows whether tangents are level or not. These are things that a railway official cannot guess from the rear end of a train.

2.—Railway officials can look over the records of a hundred miles of track and note changes that are needed in a few minutes for which it would take them days to get the data in any other way.

3.—It would cost a railroad company the price of one machine to get the data on paper that this machine will print in one day.

4.—A roadmaster can take a profile of his track, send the print to each section foreman with the necessary changes noted thereon and direct his work more successfully than in any other way. He can always see easily the chances to better a curve or level a tangent. In this way his men will always know and work on the worst places.

5.—A profile can be taken every thirty days, or oftener, and compared with previous prints made and improvements easily noted.

6.—A print can be made on a special paper, blue prints can be made from it and copies can be sent to the general manager, superintendent and engineers.

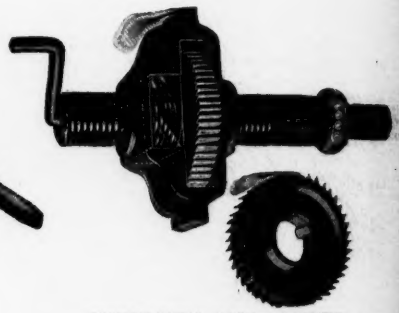
There are two patents granted in the United States and one in Canada on this invention. We are indebted to Mr. T. Ellis, roadmaster of the Northern Pacific at Tacoma, Wash., also one of the inventors, for the accompanying illustrations.

The Climax Track Drill

Very few track tools are subjected to the strain that a track drill receives. Especially is this true when boring holes of an inch and a quarter in diameter. The twisting strain of the opposed cranks added to the strain of the tremendous thrust necessary to do work of this kind quickly, calls for a very substantial machine to withstand it.

This important point was kept in mind in the design of the new Climax Track Drill, manufactured by Cook's Standard Tool Company of Kalamazoo, Mich. The drill is very well braced and the

CLIMAX TRACK DRILL IN COLLAPSED POSITION.



CLIMAX DRILL RATCHET WHEEL.

points that receive the strain have been made extremely strong.

One very important feature is that of relieving the feed device of all strain by imbedding a steel nut in the frame. This nut carries the thrust instead of the ratchet wheel. This leaves the ratchet free to revolve easily as it is not threaded internally but is keyed to a sliding fit on the feed screw. This steel nut also accomplishes another very important end. As the ratchet wheel and the feed screw revolve together, by simply tossing back the feeding-pawl the bit may be returned from the hole or forwarded to the rail by turning the small crank at the end of the feed screw. The importance of this feature is plain when one remembers that heretofore it has been necessary, in drills of this kind, to twirl the ratchet wheel around with the fingers. When, from any cause the bit becomes choked in the rail, it has heretofore been almost impossible to loosen it. With the Climax, however, the little crank almost instantly returns the bit to its original position.

The rocker-shaft or feeding-lever is forked at the end. This fork is engaged by the steel eccentric. The feed is very positive, no springs being necessary. Another novel feature in this drill is the crucible steel gear. The bevel gears are probably the weakest points in any drill, but these crucible steel ones should last for a long period with constant usage.

Ball-bearings in self-contained tool steel racers are placed between the spindle and the feed screw, which eliminate all unnecessary friction.

The manufacturers claim that this drill will easily bore holes of 1¼-inch and do it month after month and the repair requirements will be smaller than with any other drill.

CLIMAX TRACK DRILL.

Technical Publications

THE SIX CHORD SPIRAL. By J. R. Stevens, C. E. Published by The Engineering News Publishing Company, New York. Cloth binding, 68 pages, 5x7½ ins. Price, cloth, $1.25; boards, $1.00.

The six-chord spiral may be fitted to odd curves as readily as to even ones. This method of spiraling does not require the use of tables, but some special tables of the usual form may be computed from data contained in the volume.

This spiral is adapted to the curve and not the curve to the spiral of fixed offset or length. It is easily understood and applied by transitmen, who have had no previous experience with spirals. The mathematical treatment is very simple.

The spiral may be substituted between two curves by shifting the original tangent, leaving the main curves undisturbed. The spiral can be run in on the original location between two members of a compound curve. These points are illustrated by example.

Besides the many applications of the spiral which are discussed and illustrated in the volume, there is a complete treatise on the subject of spiraling old track. The author has written in clear, concise form, a volume which can be easily understood without additional reference books.

AMERICAN ELECTRIC RAILWAY PRACTICE. By Albert B. Herrick, consulting engineer, and Edward C. Boynton, general manager of the Orange County Traction Company. Published by McGraw Publishing Company, New York.

The volume is descriptive of modern electric railway practice. It does not treat the subject to any extent from a theoretical standpoint, but it contains information of practical value in the construction, operation and maintenance of railways.

Preliminary estimates are given in regard to earnings, location and surveys. This is followed by a chapter on field engineering. Railway track construction, including cost, data and descriptions of roadway sections, rails, rail joints, etc., is treated.

Other subjects are as follows: Location of the Power Station; overhead circuit construction, including data on third-rail construction; time tables and schedules, rolling stock, design of a modern car house; maintenance of overhead line; operation of the main repair shop; maintenance of equipment, and miscellaneous subjects.